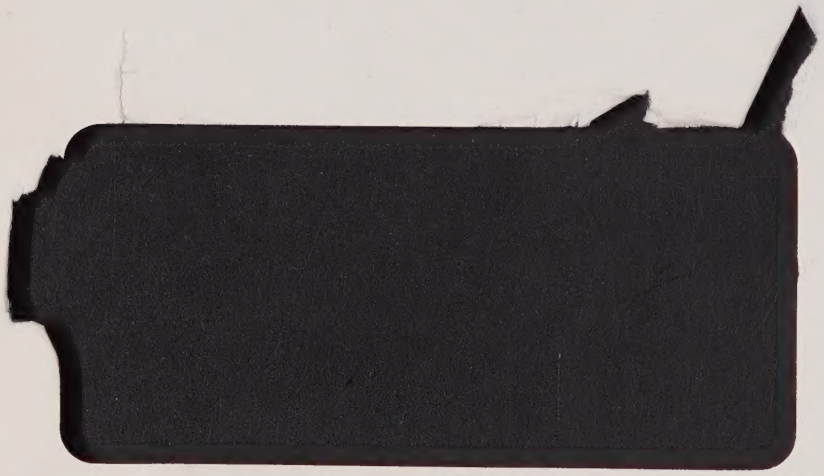
OPERATING INSTRUCTIONS
FOR
SPECIAL TWO INCH PUMPING STATION
FOR
BELL TELEPHONE LABORATORIES
B-16372

R. P. Ahrens

ULTRA-HIGH

VACUUM EQUIPMENT

Granville-Phillips Company



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GRANVILLE-PHILLIPS COMPANY
5675 EAST ARAPAHOE AVENUE
BOULDER, COLORADO 80302

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1.0 Introduction

This system was constructed by the Granville-Phillips Company for Bell Belephone Laboratories on GP Sales Order #B-16372. It consists basically of a Granville-Phillips Series 225 2 Inch Pumping Station with added roughing system, control valving, gas inleting and glass tube adaption.

1.1 System outline and schematic, DS-2545 (see pocket on rear cover).

1.2 Schematic, electrical, DS-2695 (see pocket on rear cover).

1.3 Performance Test (insert).

2.0 Operating Procedure

2.1 General

The operating instructions for all major components, which are included herein, should be read and understood before attempting to operate this system. In particular the operation instructions for the series 225 pumping station should be reviewed.

2.1.1 Precheck all components for correct operation. Check oil levels on P_1 and P_2. NOTE: After completion of factory tests, the entire system is vented and returned to atmosphere with clean dry air and all valves are closed.

2.2 Startup

Refer to Series 225 instructions for start up of system. Valves V_1, V_2, V_6 and V_7 should remain closed.

2.3 Roughing

2.3.1. With system operating normally, gauge TG1 will indicate foreline pressures.

2.3.2. Operate roughing valve switch. This valve (V_4) is controlled by a delay and will open in 2 seconds and will be indicated by the pilot lite. The foreline solenoid valve will be closed and can only be reopened by closing the roughing solenoid. NOTE: When in the roughing mode the diffusion pump is isolated and will, in time, swamp unless returned to the normal mode. This time varies depending on the pressure level at which the diffusion pump was operating when isolated. For instance at pressures of 10^{-4} Torr swamping will occur in 1 minute; at pressures of 10^{-5}, about 10 minutes. The foreline valve (V_3) is controlled by a 30 second solid state delay which resets in 100 milliseconds assuring correct foreline pressures at all times.

2.3.3. Roughing manifold pressures can be monitored on thermogauge (TG2).

2.3.4. V_2 may be opened when glass tube adaptor is properly connected.

2.3.5. Hi Vacuum manifold pressure can be monitored with Ion Gauge (IG1). When pressures 10^{-3} Torr are indicated, the roughing mode may be changed back to normal, Valve V_1 opened and Valve V_2 closed.

2.4 Shut Down

Refer to Series 225 instructions for shut down of system.

2.4.1. V_5 serves as vent valve for the diffusion pump side of the system.

2.4.2. V_6 serves as vent valve for the roughing side of the system.

2.5 Trap Rejuvenation

2.5.1. Sieve Trap

The adsorbed oil molecules and water vapor can be driven off the sieve material by periodic bakeout. This is accomplished by means of a bakeout heater in the trap. Frequency is a matter of operator choice but it is recommended that this be done on a regular basis as, for example, every Friday afternoon.

2.5.1.1 Turn on P_1, foreline pump.

2.5.1.2 Open ~~V_6~~ V_4, roughing solenoid. 35 min.

2.5.1.3 Turn on T_2, trap heater.

2.5.1.4 Close V_2.

2.5.2. LN_2 Trap

The adsorbed oil molecules and water vapor may be driven off the surfaces of the trap by periodic bakeout utilizing heat tapes wrapped around the LN_2 trap.

2.5.2.1 Turn on P_1, foreline pump.

2.5.2.2 Roughing solenoid switch in normal position. V_3 should open in 30 seconds.

2.5.2.3 Do not turn on diffusion pump.

2.5.2.4 Close valve V_1.

2.5.2.5 Bakeout trap with heat tapes or heat gun.

GRANVILLE-PHILLIPS COMPANY

VACUUM EQUIPMENT

FOR USE FROM ATMOSPHERIC
TO THE
LOWEST PRESSURES ATTAINABLE

GRANVILLE-PHILLIPS COMPANY
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OPERATING AND MAINTENANCE

INSTRUCTIONS
FOR
SERIES 225 ULTRA-HIGH VACUUM
PUMPING STATION

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UNCRATING INSTRUCTIONS

IMPORTANT: Make certain that the crate and system are always kept in the upright position. For your convenience, these stations are delivered ready to operate and contain oil in both the forepump and diffusion pump. If this oil is allowed to spill out and the system is then operated, great damage can result. If any traces of spilled oil are visible after lifting off the top of the crate in accordance with #1 and #2* below, stop further unpacking and report the damage to the shipping company and Granville-Phillips Technical Service Department.

1. Remove four screws from the bottom of each side of the crate which are marked with red arrows.

2. Carefully lift off the entire top portion of the crate leaving the crate bottom attached to the UHV pumping station. Carefully avoid switches on the front panel and the trap fill tube on the back panel.

3. Remove the lower front panel and right side panel as one faces the front of the pumping station.

4. Remove the four red nuts from the studs which hold down the station frame. These studs are located inside on the bottom of the frame.

5. Remove the four blue nuts from the studs which secure the forepump.

6. Lift off the UHV pumping station from the skid bottom making certain that all nuts, studs, blocks, and screws are appropriately replaced in the crate for return shipping. Secure the top as before. The proper return of the crate is worth $100.00 to your organization.

7. Inspect the system for obvious mechanical damage in transit. Report any damage at once to the transportation company.

*Refer to Page 8
Operating Instructions

OPERATING AND MAINTENANCE

INSTRUCTIONS

FOR

SERIES 225 ULTRA-HIGH VACUUM

PUMPING STATION

1. PRODUCTION OF LOW PRESSURES

The ultimate or lowest pressure which can be achieved in a vacuum system is attained when the rate of gas removal equals the rate of inflow from all sources. In a properly constructed system, real leaks from the atmosphere into the system are negligibly small. Thus, the gas load which the pumps must handle at low pressure comes from gases or vapors desorbing from the inside system surfaces, or from gases escaping from small pockets or crevices within the system or from the pumps.

At low pressures even a seemingly insignificant bit of contamination can prevent a system from reaching lower pressures. A single fingerprint at 10^{-10} Torr would require an orifice area of about 2.3 square feet to exhaust the gas coming from the print. A smaller orifice would conductance limit the rate of exhaust and one would not be able to reach 10^{-10} Torr regardless of the size of pump used until the contamination were removed. One square centimeter of well outgassed rubber O-ring would require about 1000 l/sec pumping speed at 10^{-10} Torr just to prevent the pressure from rising in the system.

Your new system has been carefully designed, assembled and tested to attain very low pressures. If the system is kept meticulously clean and properly operated it will quickly and reliably pump into the ultra-high vacuum range. If it is contaminated with even minute bits of high vapor pressure materials, most of the pumping speed of the system will be used, handling gas loads which should not be present. Thus the system will not be able to reach low pressures.

2. OPERATING SPECIFICATIONS

Ultimate pressure: Series 225 systems will attain a pressure of at least 5×10^{-9} Torr without bakeout when pumping on a clean stainless steel test dome (ID equal to pump ID, height at least 1.5 times pump ID) and have been so tested before shipment. Lower pressures can be achieved with proper system bakeout. All tests are made with DC 705 oil in the pump, with a metal gasket between trap and pump and between test dome and trap, and with a Bayard-Alpert ionization gauge which has been thoroughly outgassed by electron bombardment.

Pumping speed at port:

10^{-3} to 5×10^{-7}	23 l/sec
5×10^{-8}	10 l/sec
5×10^{-9}	1 l/sec

Trap liquid nitrogen capacity: 1.6 liters

Time to boil-off liquid nitrogen from trap: >15 hours

Time trapping surfaces will remain at constant temperature on one filling of liquid nitrogen: >12 hours

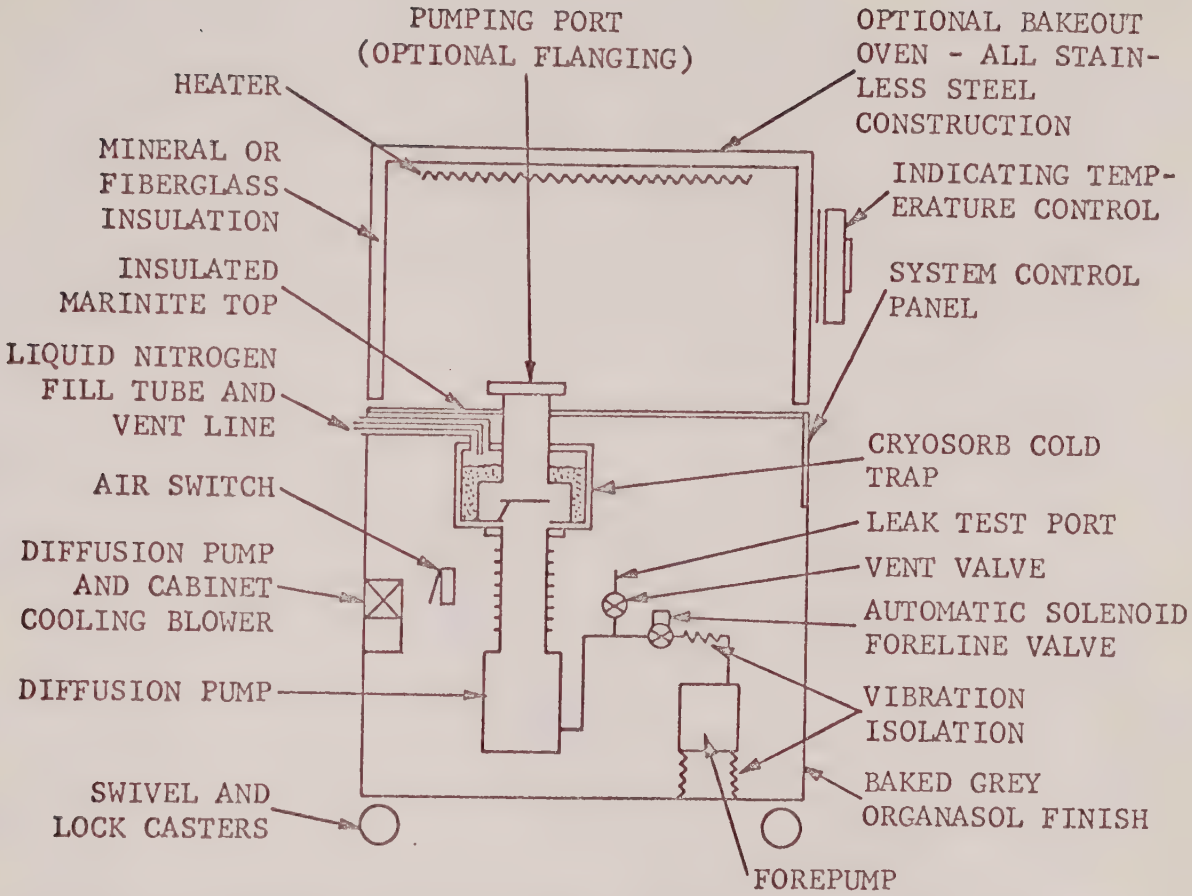

Figure 1. Series 225 Ultra-High Vacuum Pumping Station Schematic showing location of all major components.

Power requirements:	15A 110V 60 Cycle 1 Phase, 3 wire
Recommended maximum bakeout temperature:	450°C
Forepump oil:	Welch Duo Seal
Diffusion pump oil:	100cc DC 705
Bakeout oven power:	12A 220V 60CPS 1 Phase 3 wire

3. SYSTEM DESCRIPTION

3.1 General

Series 225 systems consist of a mechanical forepump, air cooled oil diffusion pump, Cryosorb* Cold Trap and associated valving, controls and cabinet as shown in Figure 1. The bakeout oven is optional equipment.

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3.2 Forepump

A two-stage 21 liter/min electric motor driven rotary pump is used to reduce the pressure in the system to about 1×10^{-3} Torr. An eccentrically mounted rotor which has two spring loaded vanes sweeps air out of the diffusion pump and exhausts it to the atmosphere. Very close fitting parts and a special low vapor pressure Duo Seal oil provide a seal against the atmosphere.

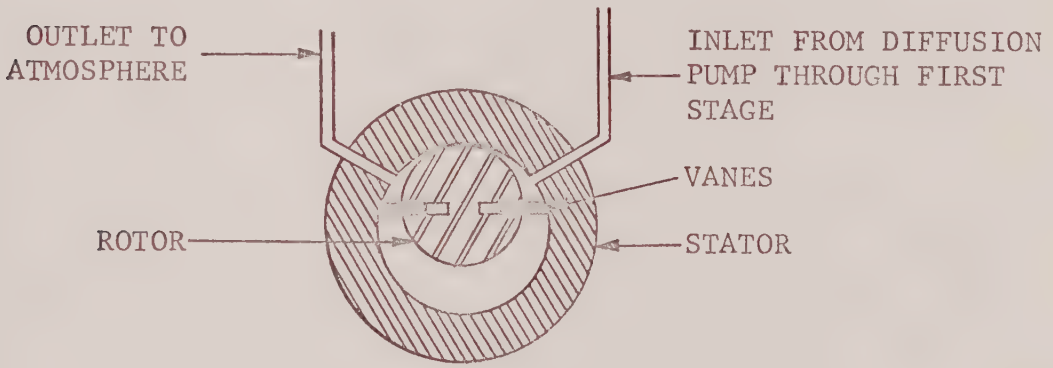

Figure 2. Mechanical Forepump Schematic (single stage shown)

3.3 Diffusion Pump

Because the forepump alone will not produce very low pressures, an air cooled diffusion pump is also employed to reduce the pressure in the system.

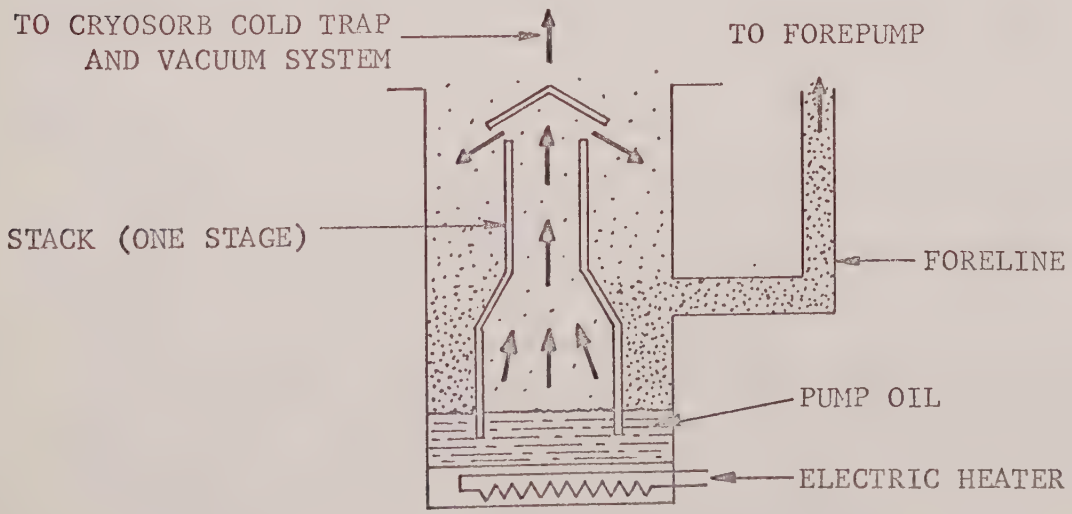

Figure 3. Schematic of Single Stage of a Diffusion Pump

A schematic of a single stage diffusion pump is shown in Figure 3. The diffusion pump used in your system is a three stage fractionating pump.

Pumping action in an oil diffusion pump is accomplished by suitably forming and directing a jet of rapidly moving oil vapor which sweeps out gas molecules which diffuse into the jet. The oil vapor is produced by boiling oil in the base of the pump. The oil vapor is condensed on the air cooled sides of the pump to be recycled through the boiler and jet assembly.

Gas molecules which diffuse into the oil vapor stream are swept along with the stream. Thus the rarefied gas at the throat of the pump is compressed and exhausted through the foreline.

An oil diffusion pump cannot exhaust directly to the atmosphere. Thus it is the function of the forepump to furnish a suitably low forepressure--less than about 100 microns. If the forepressure rises above this value the vapor jets are no longer able to maintain their integrity and the pumping action becomes erratic or ceases altogether.

The 100 micron figure mentioned above applies to heavy gases such as nitrogen or oxygen. For lighter gases such as hydrogen, the partial pressure of hydrogen in the foreline must be maintained much lower in order to achieve ultra-high vacuum in the system. The lighter gases are able to diffuse backwards through the vapor stream much more readily than heavier molecules.

The diffusion pump is filled with 100 cc of DC 705 oil which has a very low vapor pressure and is highly resistant to oxidation.

3.4 Cryosorb*Cold Trap

The function of a cold trap is to prevent oil vapors and other high vapor pressure materials from diffusing into the system without seriously impeding the flow of molecules from the system to the pump.

The Cryosorb* trap, specifically designed by Granville-Phillips for ultra-high vacuum use, is the "heart" of the system and is largely responsible for its performance.

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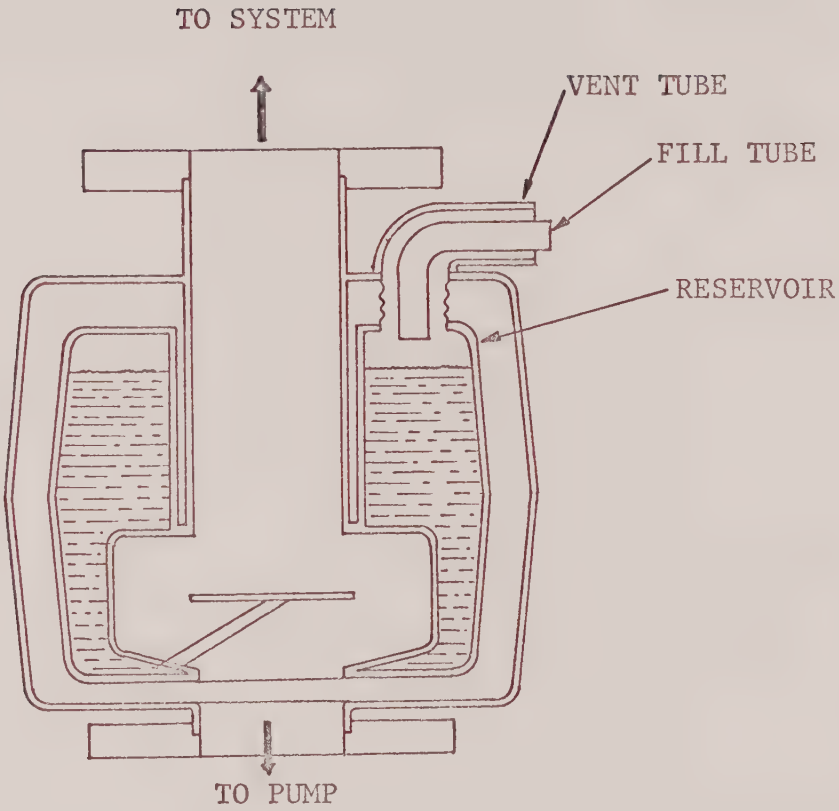


Figure 4. Schematic of 2" Trap

A unique internally insulated reservoir permits the coolant level to fall for more than 12 hours without any change in trapping surface temperature. Thus, if the trap in your system is filled every 12 hours, gases and vapors previously trapped will not be released back into the system. If the trap is filled every 15 hours or oftener, then oil molecules will be unable to creep along the interior surfaces from the pump to the system.

The trap in your system was designed for use only with liquid nitrogen. It is filled through a 3/8" diameter fill tube on the upper left back corner. Nitrogen gas is vented through the tube surrounding the fill tube. The trap is full when liquid nitrogen flows in a steady stream from the vent tube. If you wish to use an automatic filling device, use one with resistor or thermistor sensors. Thread the sensor wires through the vent tube and resolder the sensors.

3.5 Controls

The control panel contains only two circuit breaker switches, one for operation of the forepump and coolant blower and one for the diffusion pump. An electrical interlock prevents turning on the diffusion pump if the forepump is not on. An air flow switch in the blower outlet prevents turning on the diffusion pump if the blower is not on or if air flow is inadequate.

3.6 Foreline Valve

An automatic solenoid operated vacuum valve is located in the foreline between the diffusion pump and forepump. This valve closes and seals off the diffusion pump whenever the forepump is shut off or when a power failure occurs.

3.7 Leak Test Port and Vent Valve

A leak test port and vent valve are recessed into the left side of the cabinet. The system should not be vented until the diffusion pump has been cooled for at least 40 minutes with the blower operating. Even then venting should be carried out slowly to prevent carrying oil vapor into the system.

3.8 Cabinet Top

The cabinet top is made of 3/4" thick Johns-Manville Marinite. It will withstand bakeout to 450°C and may be readily drilled, tapped or sawed with ordinary tools. Typical pull out value for a 1/4-20 UNC bolt with 1/2" penetration is about 180 lbs.

3.9 Bakeout Oven, Optional Equipment

CAUTION: Dangerous voltages are present on the heating element mounted inside the top of the oven when the oven is plugged in. Do not touch the element or permit apparatus to come in contact with the element.

The bakeout oven is made entirely of polished stainless steel and insulated with fiberglass or mineral insulation.

The oven wattage has been chosen to provide 450°C temperatures when the oven is resting on the insulated system top or other suitable insulated support.

Set the desired temperature by turning the knob on the oven controller until the red hand indicates the correct temperature. Plug in the oven to 220V, 60 CPS, 15 amp power line and turn

on the power switch on the oven control panel. A few degrees temperature overshoot is normal.

More detailed instructions on the oven controller are given at the end of these instructions.

4. UNCRATING INSTRUCTIONS

(These instructions are also stapled to the outside of the shipping crate).

IMPORTANT: Make certain that the crate and system are always kept in the upright position. For your convenience, these stations are delivered ready to operate and contain oil in both the forepump and diffusion pump. If this oil is allowed to spill out and the system is then operated, great damage can result. If any traces of spilled oil are visible after lifting off the top of the crate in accordance with 4.1 and 4.2 below, stop further unpacking and report the damage to the shipping company and Granville-Phillips Technical Service Department.

4.1 Remove four screws from the bottom of each side of the crate which are marked with red arrows.

4.2 Carefully lift off the entire top portion of the crate leaving the crate bottom attached to the UHV pumping station. Carefully avoid switches on the front panel and the trap fill tube on the back panel.

4.3 Remove the lower front panel and right side panel as one faces the front of the pumping station.

4.4 Remove the four red nuts from the studs which hold down the station frame. These studs are located inside on the bottom of the frame.

4.5 Remove the four blue nuts from the studs which secure the forepump.

4.6 Lift off the UHV pumping station from the skid bottom making certain that all nuts, studs, blocks, and screws are appropriately replaced in the crate for return shipping. Secure the top as before. The proper return of the crate is worth $100.00 to your organization.

4.7 Inspect the system for obvious mechanical damage in transit. Report any damage at once to the transportation company.

5. INSTALLATION OF WORK CHAMBERS AND/OR MANIFOLDING

Connect the work chamber or manifolding directly to the pumping station port. The bakeable Marinite cabinet top can be drilled, tapped or sawed for convenient mounting of components.

Use care to keep all components scrupulously clean. Never touch vacuum surfaces with bare fingers, use clean gloves. Never attempt to plug a leak with Glyptal or other sealing compound -- remake the joint instead.

The following comments may be helpful in making the connections:

5.1 Metal-to-Metal Sealed Flanges

Inspect each flange sealing surface for nicks, scratches, lint, etc. Between each pair of mating flanges insert a new clean metal gasket using care not to mar the gasket surface. Do not touch the vacuum surfaces with bare fingers, use clean gloves. Use only Type 18-8 Stainless Steel bolts or approved equal for connecting flanges. Other bolts may be too weak or have incorrect temperature coefficients of expansion and will not maintain a seal during temperature cycling. Always torque the bolts until the stainless steel flange surfaces are in intimate contact so that the joint will be mechanically strong.

5.2 O-ring Sealed Flanges

Although O-ring sealed flanges are not as susceptible to damage as metal-to-metal sealed flanges, they nevertheless deserve special precautions.

O-rings should not be cleaned with solvents because the solvent penetrates the O-ring and causes severe outgassing in the system. O-rings may be cleaned by coating the ring with a small amount of Apiezon N or clean diffusion pump oil and carefully wiping the surface with lint free paper until clean and dry. Use clean gloves for installing O-rings.

Note that for lowest possible pressure the O-rings should be vacuum fired at the highest allowable temperature for 12 to 24 hours. Even with vacuum fired O-rings, the ultimate pressure will not be as low as with all metal seals.

5.3 Welded Connections

Welding connections are supplied as Type 304 Stainless Steel. These connections weld readily to other Series 300 Stainless

Steels except the free-machining grades. Free-machining Stainless Steels are difficult to weld leak free and are not recommended for vacuum use. Heliarc welding has been found to be entirely satisfactory. Use inside welds wherever possible. If outside welds must be made, purge the interior weld region with inert gas during welding to prevent objectionable oxides from forming.

5.4 Brazed Connections

In general, brazed joints should be avoided in the ultra-high vacuum portion of systems unless they are made in a vacuum or hydrogen atmosphere. Otherwise, fluxes must be used and these are extremely difficult to remove adequately.

5.5 Glass Systems

Glass systems should be carefully laid out with suitable stress relief between rigidly mounted portions. A convenient way of accomplishing this is to use a Granville-Phillips flex pyrex connection which consists of metal bellows-Kovar to glass combination. Alternately, two Granville-Phillips flexible glass bellows placed at right angles to one another should be used to relieve stresses. A less convenient but entirely suitable method is to use large expansion U bends in the glass tubing.

A drying tube should be used for glass blowing operations. Glass chips and flakes should be carefully excluded because they will migrate through the system and may ruin metal-to-metal sealed valves. Test all glass joints with a good leak detector or a Tesla coil. Note that a Tesla coil only gives a reliable indication at pressures above about 10^{-5} Torr.

If pure gas bottles with "breakoffskis" are to be used, install fritted glass disks between the gas bottles and the leak valves. If fritted glass disks or other suitable filters are not used, glass chips from the "breakoffskis" may be blown several feet through the system and possibly cause damage to the valves when the gas bottles are opened.

6. INITIAL START UP

Proceed as follows when all of the vacuum connections have been made and suitably leak checked.

6.1 Vent valve CLOSED

6.2 Forepump switch OFF

6.3 Diffusion pump switch OFF

6.4 Trap EMPTY AND AT ROOM TEMPERATURE

6.5 Plug power cord into 15 Amp, 115V, 60 CPS power source. Make certain system is properly grounded if only a two wire source is available.

6.6 Turn on forepump.

6.7 Turn on diffusion pump after about three minutes or as soon as forepump ceases to gurgle.

6.8 After about 20 minutes the pressure should be low enough to turn on an ionization gauge to measure the system pressure.

6.9 Fill the trap after the pressure has reached about 10^{-5} Torr. As in any liquid nitrogen trap, a continuous distribution of temperatures exists inside the trap between 77°K and room temperature. If the trap is filled at higher pressures before most of the water vapor in the system has been removed, some water vapor will condense on surfaces which are not at 77°K. For example, water condensed on surfaces at -70°C has a vapor pressure of about 2 microns. Thus, any such deposit will sublime very slowly and can hold the system pressure at say 10^{-6} Torr for many hours or even days. Thus for very low pressure work it is best to free the system of water vapor, carbon dioxide, etc. before trapping is attempted.

Refill the trap every 12 hours for best results. Filling more often will not improve system performance.

6.10 Bakeout can be started any time after the system pressure has decreased below about 1×10^{-4} Torr. It is best to start at low bakeout temperatures with a new or dirty system and gradually increase the temperature as the system cleans up.

A 300°C bakeout for 4 hours is usually sufficient to attain 5×10^{-9} Torr in small clean systems. A 450°C bakeout for 8 hours is usually sufficient to attain 5×10^{-10} Torr after the system cools to room temperature.

6.11 Bakeout of Ion Gauge

It is extremely important that the ionization gauge tube be thoroughly baked out to remove contamination which would give

an erroneously high pressure reading. A simple way to tell if a gauge is clean is to bake the gauge electrically and then switch at once to pressure measurement. If the gauge immediately indicates a low pressure reading and does not continue to drift downscale for a decade or half a decade, the gauge is fairly clean. Typically, a dirty gauge will drop one or more decades in pressure as it cools after outgassing.

One way of raising the gauge temperature higher for thorough outgassing is to wrap the gauge with an inch thick bat of glass wool or with glass wool and aluminum foil. Use caution not to heat the glass to the softening point.

7. STEP-BY-STEP PROCEDURE FOR ROUTINE START UP

7.1 Vent Valve CLOSED

7.2 Forepump Switch OFF

7.3 Diffusion Pump Switch OFF

7.4 Trap at ROOM TEMPERATURE

7.5 Turn on Forepump

7.6 Turn on Diffusion Pump after about 3 minutes. Note: If system volume is small and system is known to be tight and properly operating the diffusion pump can be turned on with the forepump.

7.7 Fill trap after about 20 minutes.

8. STEP-BY-STEP PROCEDURE FOR ROUTINE SHUT DOWN

8.1 Switch off diffusion pump.

8.2 After 20 minutes turn off forepump.

8.3 If system is to be vented, wait 40 minutes for diffusion pump to cool before turning off forepump.

8.4 Vent system very slowly so as not to sweep oil vapor into the system. Filling with a dry inert gas such as nitrogen or argon will speed subsequent pump down. CAUTION: If system is vented with trap cold, leave vent valve open until trap has warmed up. Otherwise, damaging pressure buildup in the vacuum system may occur as trapped gases are evolved from the warming trap.

If system is let up to atmosphere, wait for trap to warm before pumping down again. If trap is not warm, ice on trapping surfaces will sublime slowly and hold the pressure at a relatively high level.

9. MAINTENANCE SCHEDULE

Although these units have been designed for minimum maintenance, the following schedule is suggested for optimum performance. This schedule assumes that the station is operating continually 24 hours per day. Adjustments depending upon actual usage should be made.

Maintenance Checklist

9.1 Check mechanical pump belt.....Weekly

9.2 Check oil level in mechanical pump.....Monthly

9.3 Clean Ventilating fan.....Quarterly

9.4 Clean diffusion pump fins.....Quarterly

9.5 Change oil in mechanical pump.....Semi-annually

9.6 Change oil in diffusion pump.....Semi-annually

9.7 Clean trap.....Annually

9.8 Check and clean solenoid valve.....Annually

10. TROUBLE SHOOTING

SYMPTOM	CAUSE	REMEDY
System Pressure too High	Leak	Leak check system Repair leak, do not use Glyptal or similar sealants
	Trap has been exposed to moist air.	Let trap warm to room temperature
	Gas Inlet Valves on Manifold not sealed completely	Seal valves (Only on systems with gas inlet valves)

SYMPTOM	CAUSE	REMEDY
	Vent Valve not sealed	Seal Vent Valve
	Ion Gauge contaminated	Thoroughly bake gauge electrically
	Trap empty	Fill trap
	Diffusion pump off	Check blower, air switch, diffusion pump heater
	Solenoid Valve closed	Check voltage on valve
	Forepump low on oil	Check oil level and refill only with Duo Seal oil
	System contaminated	Bake system
	System badly contaminated	Dismantle system and clean carefully. Replace diffusion pump oil.
Diffusion pump does not operate	Air inlet blocked	Remove obstruction
	Blower not plugged in	Plug in blower
	Air switch sticking	Check and adjust
	Heater burned out	Check with ohmmeter
	Solenoid valve closed	Check voltage on valve
Forepump does not operate	Low on oil	Check level and refill only with Duo Seal oil
	Belt slipping	Tighten belt
	Oil is contaminated	Drain and refill only with Duo Seal oil

SYMPTOM	CAUSE	REMEDY
System pressure fluctuates	Normal condition with new system	Continue pumping
Bakeout oven controller out of calibration	Adjustment has slipped or been changed	Recalibrate as per Fenwal instructions
Temperature overshoots by a few degrees	Normal Condition	———
Oven does not heat	Fuses blown	Check fuses on front panel
	No Power	Check power source
	Heater burned out	Unplug and check for continuity with ohmmeter

11. ELECTRICAL SCHEMATIC

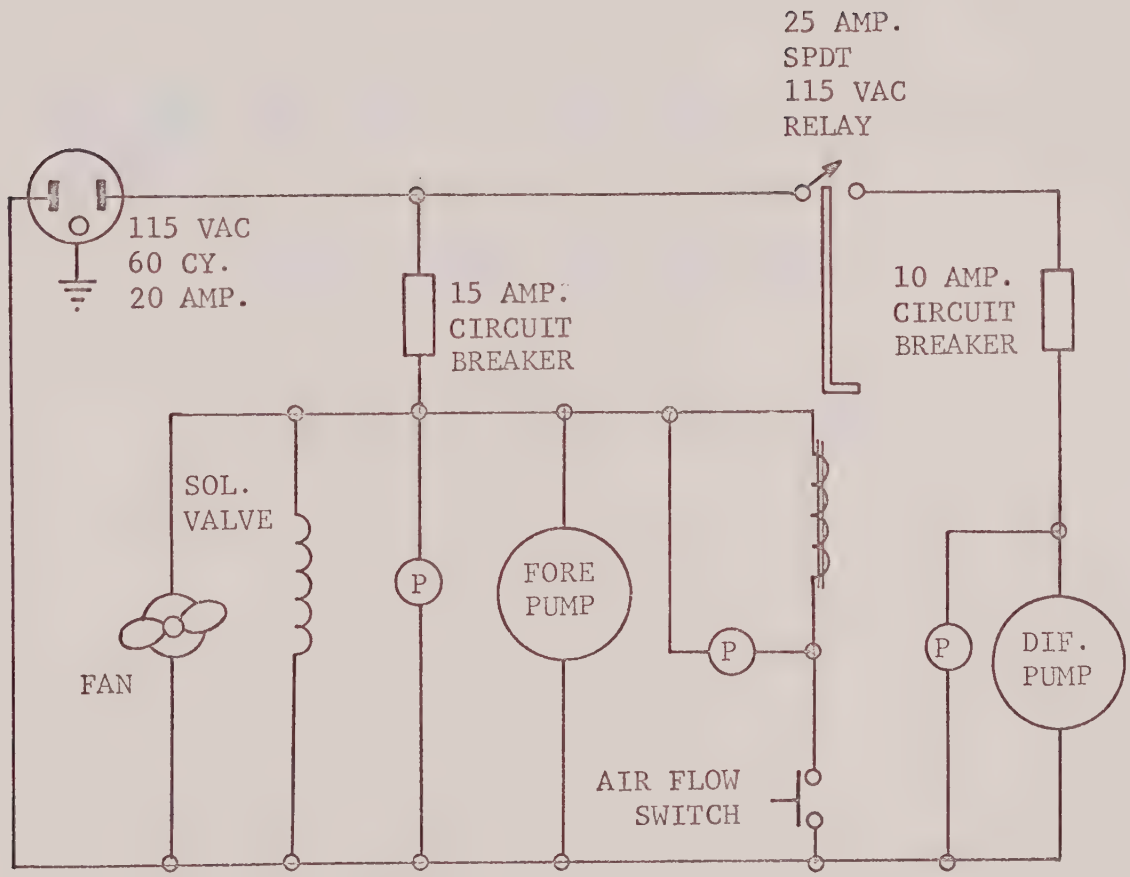


Figure 5. Electrical Schematic for Series 225 UHV Pumping Station

Granville-Phillips Company

VACUUM EQUIPMENT

FOR USE FROM ATMOSPHERIC
TO THE
LOWEST PRESSURES ATTAINABLE

Granville-Phillips Company *5675 East Arapahoe Avenue • Boulder, Colorado 80301, USA*
Area Code 303 443-7660

MODEL
1392
1392A
1397B
1398M
1399B
1400B
1402B
1403B
1404H
1405B
1405H
1406H
1410N

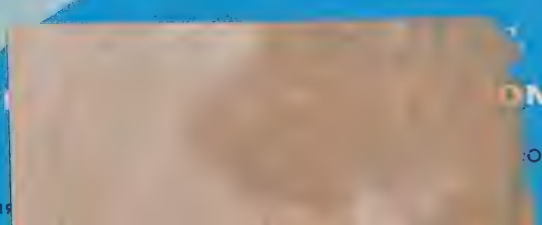
INSTALLATION OPERATION MAINTENANCE

INSTRUCTION MANUAL

WELCH

DUO-SEAL

VACUUM PUMPS



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WELCH DUO-SEAL VACUUM PUMPS are mechanical, rotary, oil-sealed, vane-type pumps of one- or two-stage construction. Their superior design and precision manufacture achieves high volumetric efficiency and low ultimate pressure — qualities which have made them the leading choice for all applications of rotary, oil-sealed vacuum pumps.

Welch's exceptionally high standards in manufacture, continuous testing and assembly by skilled craftsmen result in long life and extremely low maintenance. All pumps are thoroughly run-in and frequently tested to reach a performance level which surpasses their guarantee.

The following pages cover the installation, operation and maintenance of your Duo-Seal Pump. These instructions should be read carefully before operating the pump or attempting repairs. Complete instructions are included for routine servicing of the pump and motor.

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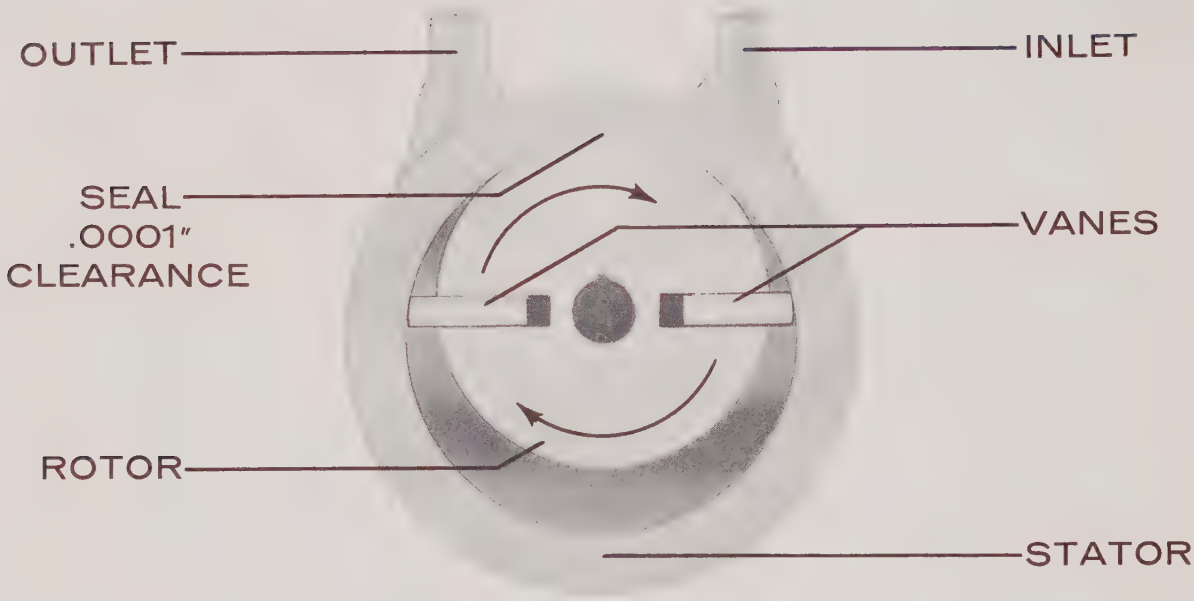


PRINCIPLES OF OPERATION

Each stage of the Welch Duo-Seal Pumps consists of a rotor, mounted concentrically on the drive shaft and positioned eccentrically in a cylindrical stator. The contact area of the rotor and stator is called the SEAL. It is a cylindrical seat machined into the stator, with the same radius as the rotor, and located between the inlet and outlet of the pump. The rotor is fitted with two spring loaded, diametrically-opposed vanes which move in and out of their slots, always pressing against the inner surface of the stator ring. Any wear on the vanes is reduced to a very insignificant amount because of a thin oil film which lubricates all parts of the pump. As a vane leaves the seal, it sweeps the air from the crescent-shaped space and forces it out the one-way exhaust valve. This operation is repeated twice each revolution, reducing the pressure in the vessel connected to the intake, thereby achieving a higher and higher vacuum. A patented feature called the Duo-Seal provides a by-pass at the seal. This by-pass carries the last increment of gas, which may escape the port, back to the exhaust stage. It eliminates the possibility of entraining the gas into the intake stage and re-pumping it.

The operating combination of stator, rotor and vanes constitutes the vital part of the pump. One of these units is used in a single-stage pump. In a two-stage pump, two of these units are connected in series and mounted on a common drive shaft for better ultimate vacuum.

VENTED EXHAUST

The presence of water or other vapors in the vacuum system can be very detrimental to the performance of the pump. They may contaminate the oil, and if corrosive, they will damage the pump parts. One method of removing such vapors is using cold traps between the pump and vacuum system. A vented exhaust valve on the pump will give additional protection.

The vented exhaust minimizes the condensation of vapors in the compression cycle of the exhaust stage by introducing an adjustable flow of atmospheric air. The diluting effect of the admitted air lowers the partial pressure of the vapor below its saturation pressure at the operating temperature of the pump. This prevents condensation and the vapors are expelled with the exhaust gases.

The vented exhaust is also helpful in removing condensed vapors from previously contaminated oil. Method of use and adjustment is described on page 5 under "Operation".

UNPACKING

Remove the pump from the shipping case with care. If any damage has occurred, file claim with the carrier immediately. Always save the shipping container for carrier inspection.

If it is necessary to communicate with your dealer or The Welch Scientific Company, please include your order number, pump catalog number and serial number to expedite replacement. *Do not return the pump to the factory* without obtaining shipping instructions.

INSTALLATION

MOUNTING

Welch Pump-Motor Sets are furnished mounted on formed steel bases, supported on rubber bumpers. These units should be placed on a firm foundation. See instructions for No. 1392 and No. 1392A Mechanical-Diffusion Pump Combinations at the end of this section.

All Duo-Seal Pumps have supporting legs drilled for mounting bolts.

The pump should be located in a clean area with good ventilation, and as close as possible to the vacuum system to which it will be attached. Adequate space should be allowed around the pump for normal maintenance, such as oil changes, belt adjustments, etc. Before operation, check belt tension and pulley alignment.

The pumps are air-cooled, eliminating the need for cooling water.

ELECTRICAL

Care should be taken to insure that the electric motor is connected to the correct voltage, phase and frequency. Check the motor wiring connection by removing motor plate and comparing connections with diagram on inside of plate. Pump-motor sets (other than explosion proof and 3 phase motors) are furnished with a switch and cord. The cord can be plugged directly into the proper receptacle.

If the electric motor to be used is not furnished by Welch, be sure that the motor, belt and pulley will operate the pump at the proper speed.

Check the rotational direction of the motor before connecting belt to pump pulley.

CONNECTION TO SYSTEM

The connecting line between the pump and the vessel to be evacuated should be as short as practical and as free from bends as circumstances permit. The inner diameter should be at least as large as the inside diameter of the pump intake. (See page 14, "Vacuum Connections and Fittings.")

A good vacuum-tight joint between the pump intake and connecting line can readily be made by sliding the correct size, heavy-walled rubber tubing (Welch No. 5518B) over the intake nipple. Insert the connecting line into the tubing so it butts flush against the nipple. Use of worm-screw band clamps is desirable, and/or sealing with vacuum wax or "Leak-Lock" (Welch Catalog No. 1372).

For permanent connections, remove either or both the intake nipple and exhaust dust cap, and screw the piping into the connections. See Page 14 for thread dimensions. Use a sealant such as "Glyptal" or "Leak-Lock" on the intake threads.

OIL LEVEL AND TYPE

To insure efficient operation, low maintenance and freedom from unnecessary noise and oil vapors, it is extremely important to use the proper type and quantity of oil. Welch Duo-Seal Oil has been specially developed over a period of years, to have the required viscosity, low vapor pressure and chemical stability. The vacuum guarantee on Welch Pumps applies only when Duo-Seal Oil is used. A sufficient supply of oil is furnished with each pump. Additional Duo-Seal Oil (Welch Catalog No. 1407K) is available in quart and gallon plastic bottles and in five gallon cans.

After pump has been running for at least fifteen minutes, check the oil level. It should be maintained between the oil-level marks, with the pump in operation. In general, the oil level will be slightly higher while the pump is running than when it is stopped. If the oil level gradually rises during prolonged operation, water or other vapor is condensing in the pump. When this occurs, the vented exhaust valve, on pumps so equipped, should be opened to purge the oil, or the oil should be changed.

The No. 1404 Pump does not have an oil-level window. In this pump the oil-level mark may be seen by removing the top plate. This requires the removal of two screws. In all No. 1404 Pumps, the top plate must be removed to add oil to the reservoir.

An explanation of the effect of too much or too little oil and oil contamination is contained on page 7, under the heading, "Oil Changes and Levels".

RECOMMENDED ACCESSORIES

Belt guards totally enclose the pulleys and belts, and are strongly recommended for the protection of personnel working near the pumps. Belt guards are furnished with mounted Nos. 1397 and 1398 Pumps and are available for all others. To service belts or pulleys, the outer half of the guard can be removed or folded down, depending on type. This can be done without use of tools. All pump bases made in the last five years have been predrilled to accept guard brackets. Older bases require drilling of two holes.

Exhaust filters are available for attachment to the exhaust port in place of the dust cap. Their use is recommended when it is necessary to operate the pump with relatively high gas flows. Any oil-sealed mechanical vacuum pump tends to discharge oil mist from its exhaust port when it is operating at high flow. Oil droplets entrained in the discharge air are removed by the combined action of a two-stage filter element. One stage consists of multiple layers of fine wire screen and the other of a special fiber. Oil is drained from the element, back through the discharge connection into the oil reservoir of the pump.

EXHAUST FILTERS:

No. 1417 for Nos. 1399, 1400, 1405, 1406 and 1410 Vacuum Pumps. (2" diameter x 4¾" high, ¾ - 20 male thread)

No. 1417A for Nos. 1402 and 1403 Vacuum Pumps. (6" diameter x 7½" high, 1 - 20 male thread)

No. 1417B for No. 1397 Vacuum Pump. (7" diameter x 10" high, 1-¾ - 20 male thread)

REPLACEMENT FILTERS:

No. 1417F for 1417 Filter; No. 1417G for No. 1417A Filter; No. 1417H for No. 1417B Filter.

BELT GUARDS

No. 41-0791 for No. 1397; No. 41-2496 for No. 1398; No. 1399G for No. 1399; No. 1400G for Nos. 1400 and 1410; No. 1404G for Nos. 1404 and 1406; No. 1405G for Nos. 1402, 1403 and 1405.

INSTALLATION OF Nos. 1392 & 1392A

These combinations consist of a No. 1400B Duo-Seal Pump with motor and a modified, two-stage metal diffusion pump, mounted on a common base. Installation is the same as that for other Welch Duo-Seal Pumps with the following additional requirements.

Connect diffusion pump intake (large diameter) to the vacuum system, preferably by brazing or silver soldering. Use as short a connection as possible with as large a diameter as possible.

Connect diffusion pump heater and electric motor to 115 V, 60 cycle power supply, with separate cords and switches provided.

Connect diffusion pump to coolant supply. No. 1392 uses a water-cooled diffusion pump and requires 0.08 G.P.M. of water at normal temperatures. Connect water supply to tubing at intake stack. The No. 1392A uses an air-cooled diffusion pump. For best results a small blower or fan with a capacity of 20 C.F.M. should be used to direct air across the cooling fins, impinging first on the intake stack.

Check system for leaks before filling diffusion pump with pump fluid.

Fill the diffusion pump with 55 c.c. of No. 1391K Octoil Pump Fluid supplied. This may be accomplished by removing the drain plug, starting the mechanical pump and sucking the pump fluid into the boiler through a clean length of rubber tubing. Use a new drain plug gasket and replace drain plug while the mechanical pump is running. Turn off mechanical pump. More complete instructions are furnished with the Nos. 1392 and 1392A pump assemblies.

OPERATION

GENERAL PROCEDURES

1. Remove intake and exhaust port plugs and install dust cap in exhaust port.
2. Check the oil level before operating and check it periodically during operation.
3. Use only clean Duo-Seal Vacuum Pump Oil.
4. All Welch Pumps, except No. 1404, contain an air filter screen in the intake port to prevent foreign particles from entering the pump. Greatest possible care should be exercised to exclude foreign particles from the intake line.
5. If corrosive vapors or excessive water vapor is evolved in the vacuum process, a cold trap should be placed in the vacuum line to prevent damage to the pump mechanism and contamination of the oil.
6. When the pump is not being used and is disconnected from the vacuum system, plug the intake to keep out dirt.
7. Carefully check connection and vacuum system for leaks.
8. Periodically check V-belt tension and pulley alignment. V-belt should be adjusted so that a firm downward pressure at the middle of the span will cause a deflection of ½" to ¾".

START-UP PROCEDURES

1. Turn on power, with intake closed (to minimize splashing).
2. Check for proper direction of rotation.
3. Check oil for proper level, with pump running.
4. The gurgling noise, characteristic of mechanical vacuum pumps when operating at high pressures, should disappear after a few seconds. If it does not, check to see if oil level is too low, or if there is a leak in the connecting lines.
5. Open intake to the vacuum system.

Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations START-UP

1. Turn on mechanical pump and evacuate the system to less than 500 microns.
2. Turn on diffusion pump coolant and heater (fresh oil will evolve the gases dissolved in it and this will tend to increase system pressure temporarily). The diffusion pump requires 20 to 30 minutes to reach normal operating temperature and full pumping capacity. If system pressure does not decrease within a few minutes after diffusion pump reaches operating pressure, turn off heater and recheck system for leaks.

VENTED EXHAUST

Vented exhaust valves are supplied with No. 1397, 1398, 1399 and 1402 Pumps, and they are available as optional accessories for the No. 1400 and 1405 Pumps. Vented exhaust valves can be field-mounted on any No. 1400 or 1405 Pumps which have serial numbers higher than 25500-0 and 26157-5 respectively. Single-stage pumps, other than the No. 1399, are not adaptable to the use of the vented exhaust.

The vented exhaust is used to prevent, or minimize, the condensation of vapors in the pump. Condensed vapors raise the vapor pressure of the oil, reducing the vacuum obtainable. These vapors can also form sludges with the oil, causing corrosion and eventual freeze-up. The vented exhaust is also used to purge previously condensed vapors which will generally re-evaporate as they are exposed to the low pressure of the intake cycle. Recondensation in the compression cycle is prevented by operating the pump with the vented exhaust valve open.

A vented exhaust is not equally effective on all vapors encountered in vacuum processing, so it does not always entirely eliminate contamination of the oil. It does, however, reduce the contamination so oil changes are not needed as frequently.

The vented exhaust valve consists of a hollow stem with a metal ball closure fitting into a conical seat in the valve port housing.

A fixed passage through the stem includes a ball check valve which prevents back-flow of air in the final compression stages. Counter-clockwise rotation of the valve stem unseats the ball, opening an air passage to the exhaust opening in the pump. One full turn of the valve stem fully opens the valve. Any fraction of a turn will open the valve correspondingly. Newer model pumps have a needle valve at the top of the valve stem to control the flow of air into the valve stem. These needle valves can be finely adjusted to any position between fully open and fully closed.

To eliminate water and other condensed vapors from forming in the pump, open the vented exhaust valve. This is done by loosening the knurled lock-ring and turning the valve stem one full turn counter-clockwise . . . tighten lock-ring. The needle valve, included on new pumps, is opened by turning counter-clockwise far enough to handle the volume of vapor. Experience with the system will enable the operator to quickly determine the proper needle valve position. As the volume of vapors diminish, the needle valve should be closed progressively. Older pumps are not equipped with a needle valve. On these older pumps, turning the valve stem one full turn counter-clockwise will give maximum venting — fractions of a full turn will give a corresponding amount of venting. When valve is fully closed, the pump will produce the highest possible vacuum under the existing conditions. If not needed, the vented exhaust valve should be closed. It is closed by turning the stem clockwise until fully seated, then adjust lock-ring seal accordingly. Finger pressure is sufficient to seat the needle valve and valve stem for a leak-tight seal.

SHUTDOWN PROCEDURES

1. Close the pump intake.
2. Turn off power.
3. Bleed in air through intake.
4. Cover intake nipple if pump is disconnected from vacuum system.
5. If pump is going to be out of service for a prolonged period, drain the oil and fill with new Duo-Seal Oil to prevent the possibility of corrosion from contamination.

Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations SHUTDOWN

1. Turn off diffusion pump heater.
2. Continue cooling until diffusion pump boiler is cool enough to touch.
3. Shut off coolant supply.
4. Turn off mechanical pump.
5. Admit air to diffusion pump intake.

NOTE—To avoid decomposition, do not expose diffusion pump fluid to pressures above 1 mm Hg (Torr), while hot. If pressure rises above 1 mm Hg, turn off pump heater immediately and maintain cooling of pump.

ROUTINE MAINTENANCE

The need for routine maintenance of the pump is usually quite apparent. In most cases the problems can be solved with very little down time. The following paragraphs cover the most common of these problems. Routine maintenance for the Nos. 1392 and 1392A mechanical-diffusion pump assemblies is at the end of this section. Major repair, requiring the disassembly of the pump, is covered later in this manual, starting on page 11.

DRIVE PROBLEMS

If pump will not run, turn off switch. Check the fuse and electrical connections to be sure power is present to the motor. If power is present, proceed as follows: Remove V-belt. Rotate motor pulley and pump pulley clockwise, by hand. If motor is stuck, it will have to be replaced or repaired. If pump is jammed, it will have to be disassembled (see "Major Repairs," page 11). If the motor turns freely by hand, turn on switch, with V-belt removed. If the motor does not work, it will

have to be replaced or repaired. If the motor operates normally and the pump pulley turns freely, replace V-belt and check the belt tension. A firm downward pressure at the middle of the belt span will cause a deflection of ½" to ¾" when the tension is correct. To increase or lessen the tension, loosen motor mounting bolts and slide motor away from or toward the pump. If the belt is too tight, it will cause excessive wear on the pump. It it's too loose, it will slip, reducing the pump's efficiency and cause excessive belt wear. Lubricate motor as directed on motor plate. The motors furnished with Welch Pumps are sleeve-bearing type. With normal use they require lubrication about every three years.

Periodically check the set screws on the pulleys and tighten if necessary.

VACUUM PROBLEMS

A decrease in the vacuum system's efficiency will be apparent by a decrease in the ultimate vacuum attainable, and/or an increase in the time required for evacuation. This failing is usually caused by leakage or unusual out-gassing. It is rarely the fault of the pumping system.

To operate at maximum efficiency, the system must be thoroughly clean. Check all connections for leaks, as outlined on page 15, "Leak Detection". If the system is completely clean and free from leaks, and unwarranted vacuum problems still exist, the pump should be checked.

The most common cause of a mechanical pump's loss in efficiency is contamination of oil. It is caused by condensation of vapors and by foreign particles. Condensed vapors increase the vapor pressure, reducing the ultimate vacuum attainable. Foreign particles and some vapors form sludges with the oil. These sludges impair sealing and lubrication, and can cause eventual "freeze-up". A vented exhaust is helpful in removing vapors, especially water, but it is not equally effective on all foreign substances; therefore, periodic oil changes are necessary to maintain efficient operation of the system. The required frequency of changing oil varies, depending on the particular system. Experience with the process will help you determine the normal period of operation before an oil change is necessary.

OIL CHANGES AND LEVEL

To change oil, disconnect the pump from the system, if possible. Warm the oil by operating the pump with the intake closed, for approximately 15 minutes. Stop the pump and remove the oil drain cap. Most of the oil will drain out freely. USE CAUTION — *oil will be hot!* The small residue remaining in the pump can be forced out by turning the pump pulley by hand, with the exhaust port closed and intake open. The oil will spurt out suddenly and should be deflected into the drain pan. *Extensive operation with the exhaust port sealed should be avoided, as excessive internal pressure may loosen the shaft seal.*

After removing all oil, close the drain and pour 3 or 4 ounces of clean Duo-Seal Oil into the intake port. Open exhaust port and run pump for a short period to completely circulate the new oil. Drain the flushing oil and force out residue, as above. Repeat flushing with new Duo-Seal Oil until flushing oil remains clean and free of color and foreign matter.

WARNING—Do not use solvents or light flushing oils. Their complete removal is difficult and their higher vapor pressures will prevent the attainment of high vacuum.

If the oil has thickened or contains sludges, it is advisable to remove the oil reservoir case and thoroughly clean out the case with clean, lint-free rags. In replacing the oil case, varnish a NEW gasket and position on the pump case. Tighten all screws uniformly. Also replace the shaft seal as explained under the heading, "Oil Leakage".

After the pump is completely flushed, refill by pouring new Duo-Seal Oil into the exhaust port. Fill to proper level indicated on the sight glass. Replace dust cap.

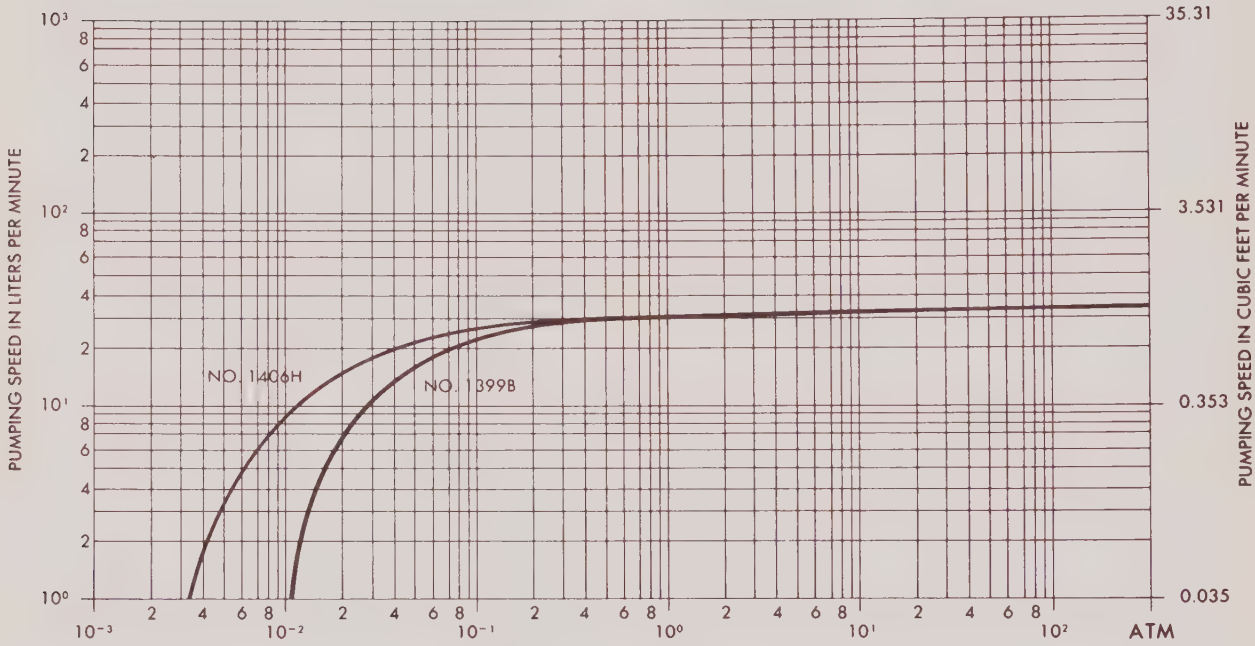
A gurgling noise is characteristic when high pressure air is drawn through the pump. It should disappear quickly as the intake pressure is reduced. If the pump continues to gurgle, the oil level may be too low. Insufficient oil does not give proper sealing or lubrication. Add oil through the exhaust port until it reaches the proper level. The oil level should be maintained between the marks on the sight glass, with the pump running. Level will drop when pump is stopped.

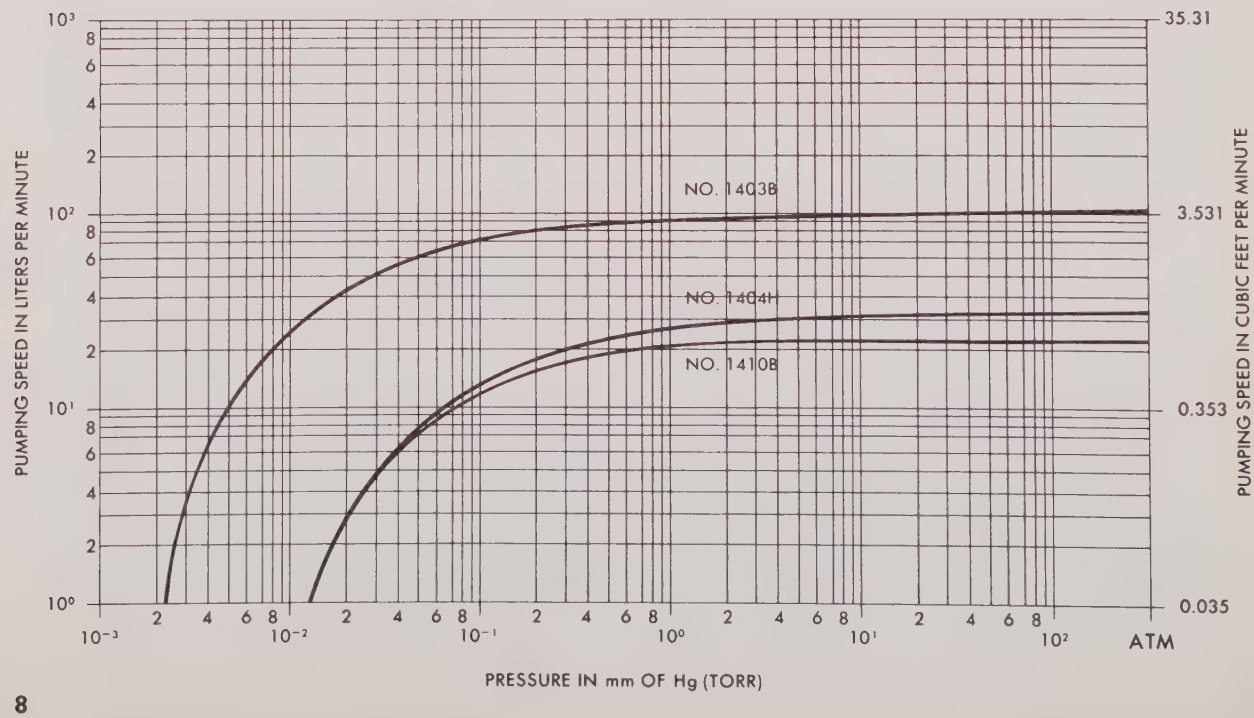
OIL LEAKAGE

Leakage of oil is readily apparent and easily corrected. The areas affected are:

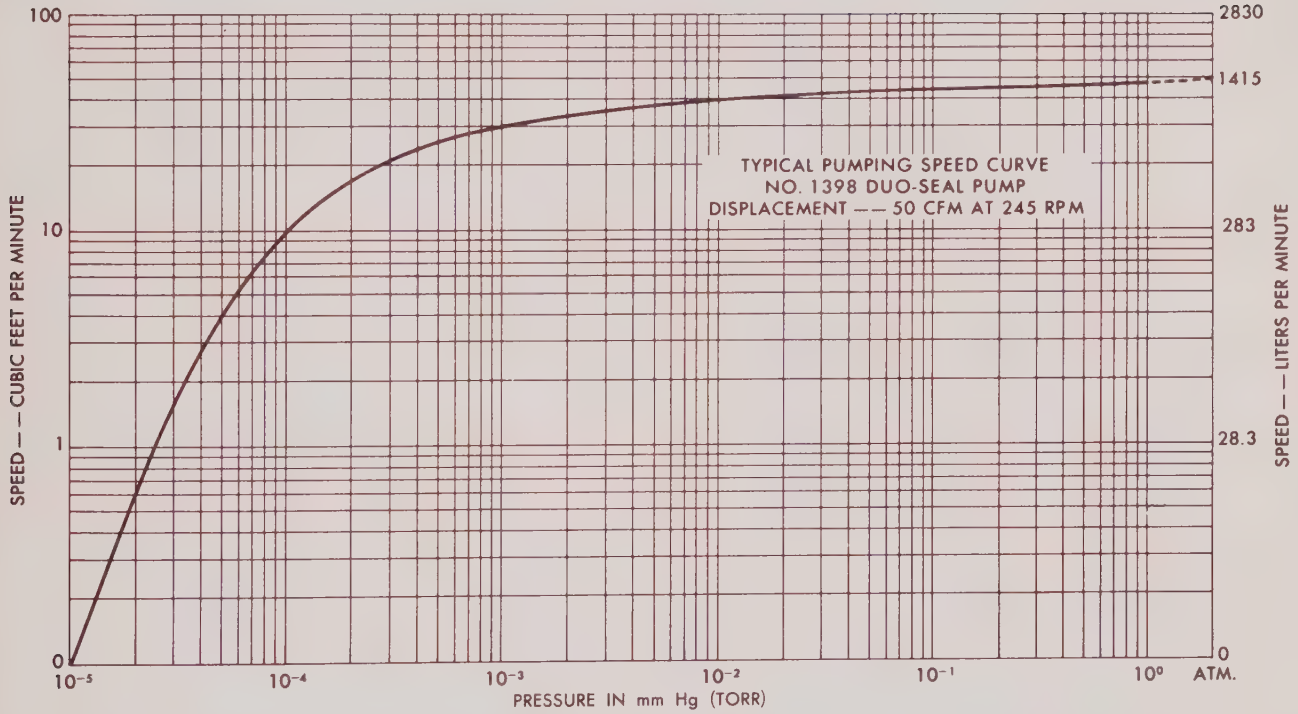
SHAFT SEAL—To replace shaft seal, drain oil, remove the pump pulley and key, and all parts of the seal. Clean the shaft and inspect it for any burrs or nicks. Carefully hone any damaged areas with fine emery paper. Hone the key way to remove sharp edges. Place new gasket on the pump casing (do not use cement). Carefully slide the replacement seal over the shaft and position against the pump housing. Align screw holes and tighten screws uniformly. *Instructions are included with replacement seals.*

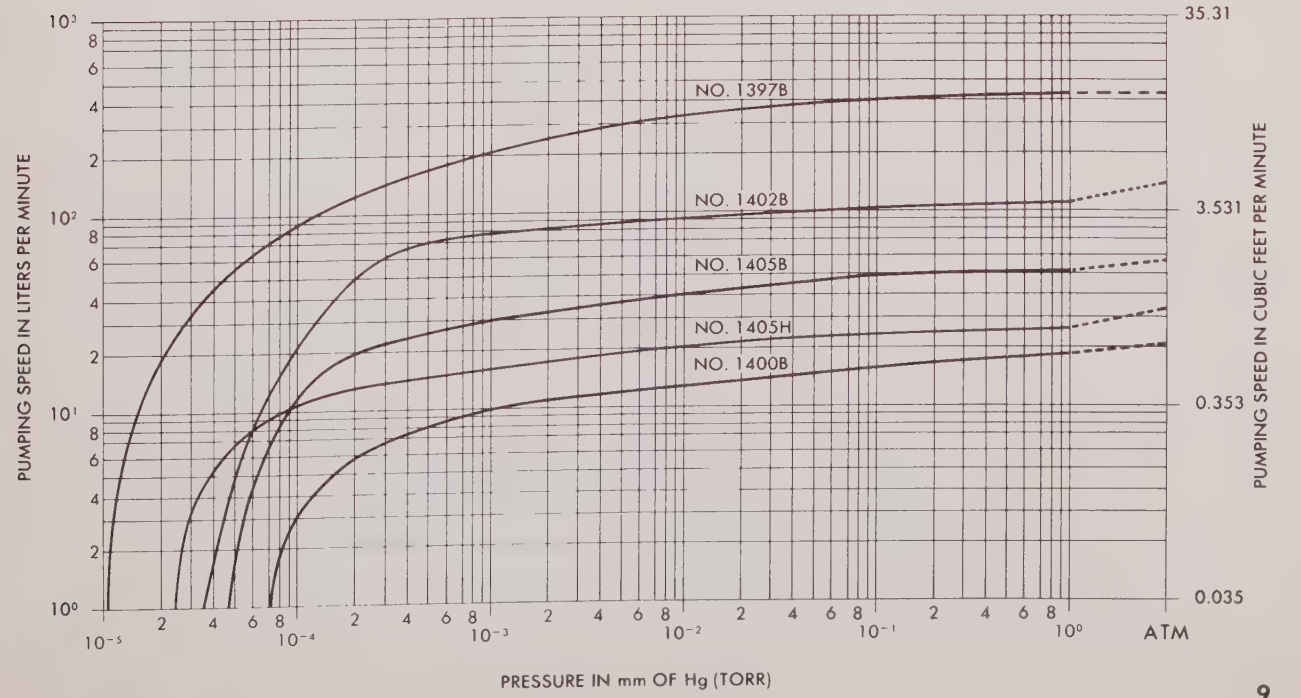
WELCH *DUO-SEAL* VACUUM





MP PERFORMANCE CURVES





OIL LEVEL SIGHT GAUGE—Unless the glass disc is damaged, it is generally only necessary to replace the inner and outer rubber gaskets. Drain oil and remove all parts of the oil level gauge. Insert new inner tension washer into counterbored seat in casing. Place glass disc in position. Mount new outer rubber washer over glass disc and into seat. Place oil window cover into position and tighten the 4 fillister head screws uniformly. The oil level gauge on the No. 1406 Pumps consist of a glass disc mounted in a metal ring. This assembly is mounted by pressing it into the opening in the case. A damaged unit can be easily knocked out.

OIL DRAIN CAP—Should a leak develop at the oil drain, replace the rubber disc within the drain cap. The old disc can be pried out with a stiff wire or pointed tool. Press the new disc firmly into the cap.

OIL CASE—If oil leaks at the oil case seal, drain the oil from the pump and remove case and gasket. Thoroughly clean the sealing surfaces of the case and pump. Varnish a new gasket and place in position. Mount case and thoroughly tighten all screws.

VENTED EXHAUST

Should the seat of the needle valve wear so that it will not seal with hand pressure, the valve stem should be replaced.

AIR FILTER REMOVAL AND CLEANING

With the exception of No. 1404 Pumps, all Welch Duo-Seal Pumps are equipped with an air filter screen. It is located below the pump intake port and functions as a trap for solids, which could cause damage to the pump. Such particles are usually the result of an implosion in the vacuum system. Unless the screen has been damaged, the filter may be removed and cleaned in the following steps:

1. Turn off the pump. (Drain oil in No. 1406 Pump)
2. Remove the intake cover.
3. Lift out air filter. (The air filter on the No. 1398 is a two piece screen attached to the intake elbow.)
4. Tap filter on clean disposable surface to remove solid particles. If further cleaning is required, rinse thoroughly in clean acetone followed by a rinse in clean alcohol and then a rinse in distilled water. Dry in stream of hot, dry air.
5. Replace the cleaned filter in intake area.
6. Use a new intake cover gasket and coat both sides with varnish. (The 1398 has a rubber O-ring rather than a gasket that should be replaced.)
7. When varnish is tacky, mount gasket in position on pump casting.
8. Replace intake cover and tighten screws evenly.
9. Fill pump with clean Duo-Seal Oil (Check level after running pump for a few minutes.)

Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations

The No. 1400 mechanical pump should be maintained and repaired as directed in the preceding instructions. The following procedures should be followed as routine maintenance of the diffusion pump.

OIL CHANGE—The pump fluid should be inspected periodically for color change and odor. If the fluid is slightly darkened and has no odor, a simple change of fluid is normally all that is needed. Follow the technique described under "Installation Procedures". If the fluid has developed a noticeable odor, it is recommended that the pump be cleaned in the following method.

CLEANING—Remove diffusion pump from system. Thoroughly drain oil through drain outlet (slight warming is helpful). Rinse pump with acetone and fill with a 50% solution of Caustic Soda (use care in handling). By using pump heater, boil Caustic Soda solution in pump for approximately 30 minutes. Drain caustic solution and rinse with clean, hot water. Rinse with acetone and dry with stream of warm, dry air. Replace drain plug and reinstall pump in system (replace drain plug gasket each time a plug is removed). Fill pump with 55 cc. of new "Octoil" pump fluid.

PUMP HEATER—If burn-out occurs, the heater can easily be removed and replaced. Remove holding nut at bottom of boiler and lower heater to remove. *Additional instructions are included with the pump.*

CHECKING PUMP PERFORMANCE

An excellent criterion of the condition of a mechanical pump is the ultimate vacuum it will achieve. This can be easily measured by connecting a suitable gauge to the intake of the pump and operating the pump until the highest vacuum reading is obtained.

This procedure can be used as a quick test to determine the need for maintenance and repair. Also, as a final test after all the necessary routine maintenance procedures have been followed. If the pump does not achieve or closely approach the performance of a new pump, the need for major repair is clearly established. Welch Duo-Seal Pumps are fully tested at the factory with upright, untrapped McLeod gauges. Other gauges, such as the Pirani or Thermocouple vacuum gauges can be used if allowance is made for the inherent difference in readings. See "Vacuum Techniques" in this manual for the explanation of gauges.

MAJOR REPAIRS

WELCH REPAIR SERVICE

With proper care, Welch Duo-Seal Vacuum Pumps can be depended on to give many years of reliable service. Should major repairs, which require disassembly of the pump mechanism, become necessary, it is strongly recommended that the pump be returned to the factory for reconditioning.

The basic working parts of Duo-Seal Pumps are machined to very close tolerances and require assembly on special fixtures, and with special tools by mechanics who are highly skilled at this work. It is our experience that the majority of pumps repaired by others fail to operate with maximum efficiency. It is usually still necessary to return them to the factory for proper repair.

The Welch Scientific Company maintains complete repair departments strategically located at the addresses shown on the back page. These facilities are well equipped and staffed with experts to insure prompt reconditioning of all returned pumps. Broken, worn, scored or corroded parts are replaced with new parts and the pump is thoroughly run-in and tested until it exceeds the performance requirements of the original guarantee.

WELCH EXCHANGE SERVICE

A rapid pump exchange service is offered by Welch through all of its offices to save customers the normal down-time required for factory reconditioning. A pool of reconditioned pumps is maintained for this service. Under this plan, a customer's repairable pump will be replaced by a factory reconditioned pump of the same catalog number. The prices for this exchange are as follows (subject to change without notice):

PUMP CAT. NO.	REPLACEMENT CHARGE PLUS CUSTOMER'S REPAIRABLE PUMP	PUMP CAT. NO.	REPLACEMENT CHARGE PLUS CUSTOMER'S REPAIRABLE PUMP
1397	$225.00	1403	$90.00
1398	500.00	1404	70.00
1399	45.00	1405	95.00
1400	60.00	1406	70.00
1402	135.00	1410	45.00
F. O. B. Our Plant or Branch			

Exchange Service Instructions—Simply order a factory reconditioned replacement pump of the same catalog number as the pump you wish to replace. It will be shipped to you immediately. Your pump may then be returned to the factory in the same container. You will be billed the full price of the replacement pump, at time of shipment. On receipt of your pump at the factory, a credit memorandum will be issued to you, covering the difference between the billed charge and the exchange allowance for your pump.

If your pump is not a standard model, the cost of parts and labor necessary to convert it to a standard model will be added to the cost of the replacement pump. If your pump is not repairable, you will be notified. You may then purchase a new pump and return the replacement to us when you receive the new unit. *Return the pump only—do not send motor or base.*

REPLACEMENT PARTS ORDERING INSTRUCTIONS

The parts list on the next page includes all of the items necessary to affect the repairs or replacements described in this manual. The numeral in parentheses, preceeding the part number, indicates the total quantity required of the item. When ordering replacement parts, list the quantity required, the part number and description. Shipment will be made immediately from stock.

REPLACEMENT PARTS LIST

DESCRIPTION OF PARTS	PUMP CATALOG NUMBERS AND PART NUMBERS									
	1397	1398	1399	1400	1402	1403	1404	1405	1406	1410
EXHAUST PORT DUST CAP.	41-1501		41-1345	41-1345	41-0612	41-0612		41-1345	*41-1345 or 1151C	
INTAKE										
Nipple	41-1493		41-0920	41-0920	41-0993	41-0993	41-0924	41-1274	41-0920	41-0920
Nipple Washer	41-0961				41-0491	41-0491	41-0570	41-0409		
Cover Gasket	41-1495		41-2375	41-0383	41-0234	41-0234		41-1308	41-1310	41-0258
Air Filter Screen	41-0937	41-2523 41-2524	41-0306	41-0890	41-0660	41-0660		41-0891	41-0877	41-0306
OIL CASE GASKET	41-1496	41-2518	41-1052	41-1052	41-0403	41-0403		41-1308		41-1052
OIL DRAIN CAP	41-1151	41-2499	41-1166	41-1166	41-1166	41-1166	41-1166	41-1166	41-1166	41-1166
OIL DRAIN CAP DISC	41-1172		41-1192	41-1192	41-1192	41-1192	41-1192	41-1192	41-1192	41-1192
OIL LEVEL GAUGE										
Tension Washer	41-1266	41-1266	41-1266	41-1266	41-1266	41-1266		41-1266		41-1266
Glass Disc	41-1268	41-1268	41-1268	41-1268	41-1268	41-1268		41-1268	41-0555	41-1268
Outer Gasket	41-1267	41-1267	41-1267	41-1267	41-1267	41-1267		41-1267		41-1267
Window Cover	41-1061	41-1061	41-1061	41-1061	41-1061	41-1061		41-1061		41-1061
SHAFT SEAL	41-1491	41-2491	1401E	1401E	1401D	**1401A or 1401E	1401E	1401E	1401E	1401E
Gasket	41-1494	41-2515	included	included	included	included	included	included	included	included
Screws	(4)2-01-6120	2-01-0110	included	included	included	included	included	included	included	included
VALVE, EXHAUST										
Clock Spring	41-2161		41-1239	41-1239	41-2161	41-0695	(2)41-1239	41-1281	41-1281	41-1239
VALVE, EXHAUST STAGE PRESSURE RELIEF										
Clock Spring	41-0992	41-2506			41-0992	41-0992				
Steel Ball	4-40-1200	4-40-2000			4-40-1200	4-40-1200				
VALVE, FIRST STAGE CONVERSION										
Gasket	41-1508									
O-Ring	41-1507	41-1507								
Spring Unit	41-1504	41-1504								
Bellows	14-1505	41-1505								
Valve					(2)41-2157					
Spring					(2)41-2158					
VALVE, FIRST STAGE PRESSURE RELIEF										
Valve	41-2248	41-2398								
Spring	41-2244	41-2507								
Tension Strip	41-2247	41-2485								
PRESSURE CROSS			1399T							41-1186
Adapter										41-1184
PUMP PULLEY	41-1492	41-2510	41-2192	41-2191	41-2174	41-2194	41-2194	41-2194	41-2194	41-2191
Key	41-1490	41-2514	41-0624	41-0624	41-0624	41-0624	41-0624	41-0624	41-0624	41-0624
DUO-SEAL OIL	1407K	1407K	1407K	1407K	1407K	1407K	1407K	1407K	1407K	1407K
EXHAUST FILTER	1417B	41-2495	1417	1417	1417A	1417A		1417	1417	1417
Repl. Element	1417H	41-2516	1417F	1417F	1417G	1417G		1417F	1417F	1417F
VENTED EXHAUST VALVE	included	included	included	1414	included			1414A		
Repl. Stem Assembly	41-2289	41-2497	41-2289	41-2289	41-2348			41-1258		
O-Ring	41-2364		41-2364	41-2364				41-2364		
MOUNTING PARTS										
BASE	41-1475	41-2475	41-0752	41-0788	41-2052	41-0779	41-1295	41-0794	41-0753	41-0788
Rubber Feet	(4)41-0588		(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929	(4)41-0929
Screws	(4)2-01-0312		(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708	(4)2-02-5708
Nuts	(4)2-35-3800									
PUMP										
Bolts	(4)2-01-0516	(8)2-01-0520	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(2)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2 01-0312
Washers	(4)2-63-0593	(8)2-63-0593	(4)2-61-3100	(4)2-61-3100	(4)2-61-3100	(4)2-61-3100	(2)2-61-3100	(4)2-61-3100	(4)2-61-3100	(4)2-61-3100
Nuts	(4)2-31-2521	(8)2-31-2521	(4)2-35-3800	(4)2-35-3800	(4)2-35-3800	(4)2-35-3800	(2)2-35-3800	(4)2-35-3800	(4)2-35-3800	(4)2-35-3800
MOTOR	**1 H.P.**	**3 H.P.**	**⅓ H.P.**	**⅓ H.P.**	**½ H.P.**	**½ H.P.**	**⅓ H.P.**	**⅓ ½**	**⅓ H.P.**	**⅓ H.P.**
Mounting Strips	(2)41-0669		(2)41-0670	(2)41-0670	(2)41-0669	(2)41-0669	(2)41-0670	(2) (2) 41-0670 41-0669	(2)41-0669	(2)41-0669
Bolts	(4)2-01-0312		(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312	(4)2-01-0312
Pulley or Clutch	41-0995	41-2513	41-2377	41-0549	41-1277	41-1247	41-0549 41-1181	41-1181 41-1277	41-0549	41-0549
V-BELT	(2)1397A	(4)41-2512	1399A	1400A	1405A	1405A	1406A	1405A	1406A	1400A
CORD, POWER, 115V	41-2500		41-1058	41-1058	41-1058	41-1058	41-1058	41-1058	41-1058	41-1058
230V	41-2551		41-1057	41-1057	41-1057	41-1057	41-1057	41-1057	41-1057	41-1057
BELT GUARD	41-0791	41-2496	1399G	1400G	1405G	1405G	1404G	1405G	1404G	1400G

*Use No. 1151C Dust Cap on all Model 1406 Pumps with serial number below 3956
**Use No. 1401A Shaft Seal on all Model 1403 Pumps with serial number below 5132

No. 1392 and 1392A MECHANICAL-DIFFUSION PUMP COMBINATION REPLACEMENT PARTS

DESCRIPTION OF PARTS	No. 1400 DUO-SEAL PUMP (SEE LARGE TABLE, THIS PAGE)	No. 1392 DIFFUSION PUMP (Water-Cooled)	No. 1392A DIFFUSION PUMP (Air-Cooled)
DIFFUSION PUMP		1391	1394
Heater—135 Watt, 115 Volt		1391H	1391H
Octoil Pump Fluid			
150 ml.		1391K	1391K
500 ml.		1391L	1391L
Silicone Pump Fluid			
DC-702—200 ml.		1391T	1391T
—500 ml.		1391R	1391R
DC-703—200 ml.		1391U	1391U
—500 ml.		1391S	1391S
DC-704—500 ml.		1391W	1391W

PUMP SPECIFICATIONS

PUMP PERFORMANCE

A vacuum pump is best described by its pumping speed, in volume per unit of time, at various pressures. *Example: 100 liters/minute at 0.1 micron.* This measurement is independent of the vacuum system with which it is used. An examination of the speed curves on pages 8 and 9 will show that Welch Duo-Seal pumps maintain high volumetric efficiency, almost down to their ultimate vacuums. Another important feature of a vacuum pump is the ultimate vacuum that it can obtain.

The above data is necessary to determine the proper size and type to best obtain the desired results, with a specific vacuum system.

WELCH DUO-SEAL VACUUM PUMP SPECIFICATIONS

PUMP CAT. NO.	ULT. PRESSURE mm Hg (McLeod)	FREE AIR DISPLACE. (liters/min.)	NO. OF STAGES	APPROX. PUMP SPEED (RPM)	VENTED EXHAUST	OIL CAPACITY (milliliters)	PUMP PULLEY DIA.	RUBBER TUBING BORE	INTAKE PORT THREAD
*1392	1×10^{-6}	600.(1×10^{-4})				55			
1397	1×10^{-4}	425.	2	365	Included	1230	12″	1-5/8″	1-3/4″—20
1398	1×10^{-4}	1400.	2	245	Included	2500	19″		
1399	1.5×10^{-2}	35.	1	750	Included	450	7″	7/16″	3/8″ IPS
1400	1×10^{-4}	21.	2	450	Optional	550	7″	7/16″	3/8″ IPS
1402	1×10^{-4}	140.	2	525	Included	2200	10″	13/16″	1″—20
1403	5×10^{-3}	100.	1	375		1400	10″	13/16″	1″—20
1404	2×10^{-2}	33.4	1	300		2300	10″	5/8″	
1405B	1×10^{-4}	58.	2	525	Optional	250	10″	5/8″	3/4″—20
1405H	or 5×10^{-5}	33.4	2	300	Optional	250	10″	5/8″	3/4″—20
1406	5×10^{-3}	33.4	1	300		60	10″	5/8″	3/8″—IPS
1410	2×10^{-2}	21.	1	450		450	7″	7/16″	3/8″—IPS

*No. 1392 Mechanical Pump Specifications are the same as No. 1400 in table.
No. 1392 Diffusion Pump Specifications are listed in table.

946 Milliliters = 1 Quart

MOTOR SPECIFICATIONS FOR WELCH DUO-SEAL VACUUM PUMPS

(to operate pump at proper speed)

PUMP CAT. NO.	MOTOR RATING		MOTOR PULLEY		BELT GUARD
	H.P.	R.P.M.	DIAMETER	BORE	
1397B	1	1725	2-1/2″	5/8″	Included
1398M	3	1160	4″	1-1/8″	Included
1399B	1/3	1725	3″	1/2″	Optional
1400B	1/3	1725	2″	1/2″	Optional
1402B	1/2	1725	3″	5/8″	Optional
1403B	1/2	1725	2-1/4″	5/8″	Optional
1404H	1/3	1725	2″	1/2″	Optional
1405B	1/2	1725	3″	1/2″	Optional
1405H	1/3	1725	2″	1/2″	Optional
1406H	1/3	1725	2″	1/2″	Optional
1410B	1/3	1725	2″	1/2″	Optional

N.B. When ordering motor, specify voltage.

VACUUM TECHNIQUES

VACUUM CONNECTIONS AND FITTINGS

The choice of line sizes and fittings, such as valves, can have a very marked effect on the pumping speed at the vacuum vessel. Any connection placed between the pump and the vessel creates an impedance to the flow of gas. This is particularly true at low micron pressure where the gas flow is substantially molecular in character. It is then dependent on the kinetic activity of the molecule, bringing it to the intake of the pump.

It has been shown that the conductance of a tube is proportional to the cube of the diameter (D^3) and inversely proportional to its length (L). Therefore, it is imperative that the connecting lines be as large in diameter and as short in length as practical. For best results, the diameter of the connecting tube should be as large as the diameter of the pump intake. The effect of line impedance on the net pumping speed (S) can be seen in the following relationship:

$$1/S = 1/S_1 + 1/C$$

(S_1 is speed of pump in liters per second. C is the conductance of the tubing.)

To avoid a large reduction in pumping speed at the vacuum vessel, it is clear that the conductance of the line must be considerably greater than the speed of the pump. For example, if the conductance is equal to the speed of the pump, the net speed will be one-half that of the pump.

If metal piping or tubing is used, it is preferable to solder or braze all connections. Where threaded joints must be used, screw the members together several turns, coat the remaining threads with "Glyptal" or "Leak-Lock" and screw together tightly. Flanged connections with Elastomer O-ring gaskets make excellent demountable joints.

Where glass tubing is used between the system and pump intake, joints can be made by butting the ends of the two sections together in a short section of rubber tubing. This type joint can also be used with metal-to-metal or glass-to-metal tubing. After assembly, coat the ends of rubber tubing with vacuum grease, such as DC Silicone Grease (available from Welch). Permanent glass-to-metal seals can be made by the use of "Kovar" glass-to-metal seals.

Standard tapered and ball-and-socket joints should be coated with a thin film of vacuum grease before assembly.

VALVES

Metal valves or glass stopcocks are generally used in the connecting line between the system and the pump. They provide a means of isolating the pump from the system. To minimize the impedance of flow, the valve openings should be as large as possible. Stopcocks should be lubricated with vacuum grease.

TRAPS

Where corrosive vapors or large quantities of condensable vapors result from vacuum processing, a cold trap should be used in the connecting line to the pump. It will help prevent damage to the pump mechanism and contamination of the oil.

The cold trap is installed so the vapors come in contact with the surface of the trap and are condensed. Commonly used refrigerants are liquid nitrogen or dry ice and acetone. The refrigerant to be used depends on the freezing point of the contaminants. A variety of glass cold traps are available from Welch.

When using a cold trap, the refrigerant should be maintained at a high level, to prevent warm-up of the trap. Warm-up of the trap may allow re-evaporation of the condensed vapors. The refrigerant cavity opening should not be obstructed, as the refrigerant boil-off can produce dangerously high pressures. If the trap becomes saturated, it should be disconnected from the system and the condensed vapors removed from the trap. An increase in pressure in the vacuum system will normally indicate that the trap has become saturated. When this occurs, the vapors are being evolved faster than they can be carried away.

To clean the trap, remove the refrigerant and allow the trap to warm up. Rinse off the condensed vapors with a suitable solvent. Thoroughly clean and dry the trap before reinstalling in the system.

VACUUM GAUGES

The type vacuum gauge to be used is determined largely by the pressure range to be measured. Pressures in the range produced by Welch Duo-Seal Pumps can be covered by McLeod, Dubrovin, Pirani or Thermocouple type gauges.

The McLeod gauge is used where high accuracy of measurement is required. The Pirani and Thermocouple gauges are electrical and give continuous readings of the total pressure. They are preferred where rapid pressure changes occur. The McLeod gauge does not measure condensable vapors; therefore, if vapors are present it will generally read lower than electrical gauges.

For higher vacuums in systems employing diffusion turbo-molecular or ion pumps, the hot filament ionization or the Philips gauge is used.

LEAK DETECTION

The importance of eliminating all leaks in a vacuum system is obvious when it is realized that a leak into the system, at atmospheric pressure, expands in volume by a factor of 750,000 to 10,000,000 or more. The pump must remove this added volume to maintain the desired vacuum. Fortunately a number of effective techniques for leak detection have been developed.

Large leaks can be located by pressurizing the system and painting the suspected area with a thick soap solution. Escaping air will produce soap bubbles.

Small leaks in glass systems can be located by probing with a Tesla Coil (available from Welch). This instrument is a high frequency, ungrounded, high potential spark coil with a pointed electrode. The discharge from the coil will pass through any minute opening and produce a pink glow at the location of the hole. In using a Tesla Coil, the electrode point should be held ¼" to ½" from the glass. It is not recommended for use in very thin-walled systems or adjacent to glass-to-metal seals.

Small leaks can also be detected by spraying a suspected area with acetone or gases rich in hydrogen, and observing a sudden change in pressure reading on an electrical gauge. (Pirani or Ionization type gauge). The difference in calibration of these gauges, for air and other gases, will produce a distinct change in the pressure reading. To use this method of detection, the system must be under vacuum and the gauge sensing tube must be located between the pump and the area to be probed. *Use extreme caution, as these materials are highly flammable!*

Locating very fine leaks requires a helium-sensitive, mass spectrometer leak detector. This instrument will locate leaks which cannot be detected by any other method. Numerous fine leaks can have a total effect of a large leak.

REPAIRING LEAKS

It is preferable that a permanent repair be made whenever a leak is located. Rewelding welded joints, refusion of glass or soldered joints, etc., are done by normal methods. Gasketed joints, which cannot be sealed by further tightening of bolts, should have the gasket replaced and/or the seal reground. Threaded joints should be loosened and the threads coated with "Glyptal" or "Leak-Lock", then retightened.

Temporary repairs can frequently be made by painting the area with "Glyptal" or "Leak-Lock".

BIBLIOGRAPHY

Scientific Foundation of Vacuum Technique, Saul Dushman, (John Wiley & Sons, Inc.) 1962.

High Vacua, Swami Inanananda, (D. Van Nastrand Do., Inc.) 1947.

Vacuum Equipment and Techniques, Guthrie and Wakerling, (McGraw-Hill) 1949.

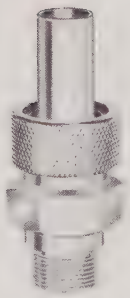
Procedures in Experimental Physics, J. Strong, (Prentice Hall) 1938.

High Vacuum Technique, J. P. Yarwood, (Chapman & Hill) 1955.

QUICK DISCONNECT COUPLING ASSEMBLIES

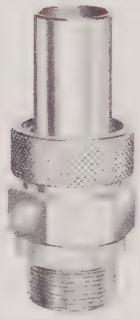
No. 1393A.

for pumps
1399
1400
1406
1410



No. 1393B.

for pump
1405



No. 1393C.

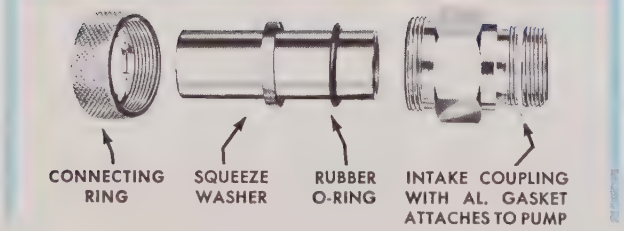
for pumps
1402
1403

No. 1393D.

for pump
1397

FOR EASY CONNECTION OF ANY METAL OR RUBBER TUBING OF PROPER DIAMETER

for Welch DUO-SEAL® **pumps**



The Welch Quick Disconnect Coupling, when screwed into a Duo-Seal Pump instead of the standard intake nipple, permits direct, rapid attachment of metal or rubber vacuum tubing. The O-ring joint provides a vacuum-tight seal and permits quick disassembly. It is not necessary to dismantle the vacuum line when the pump must be removed. Simply unscrewing the threaded ring releases the connection.

Each coupling includes a short, stainless steel intake tube onto which rubber tubing may be slipped if desired. This intake tube should be replaced by a terminal tube of the same O.D. when a metal vacuum line is used.

QUICK DISCONNECT COUPLINGS

Cat. No. 1393A. For Model 1399, 1400, 1406 and 1410 Pumps. Intake tube ½" O.D. **Each, $6.00**

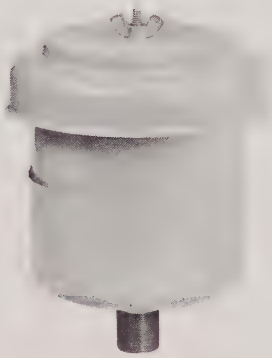
Cat. No. 1393B. For Model 1405 Pump. Intake tube ⅝" O.D. . . . . **Each, $7.50**

Cat. No. 1393C. For Model 1402 and 1403 Pumps. Intake tube ⅞" O.D. . . . . **Each, $8.50**

Cat. No. 1393D. For Model 1397 Pump. Intake tube 1¾" O.D. . . . . **Each, $26.00**

EXHAUST FILTERS

No. 1417.
for pumps
1399
1400
1405
1406
1410

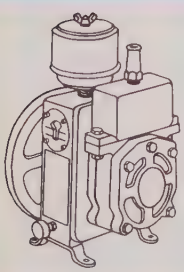


No. 1417A.
for pumps
1402
1403

No. 1417B.
for pump
1397

ELIMINATE OIL MIST AROUND EXHAUST KEEP VACUUM PUMP AREA CLEAN

Welch Duo-Seal Pumps operating at high pressures emit far less oil vapor from the exhaust than any other equivalent pump. Nevertheless, if you operate your Duo-Seal Pump frequently at the higher pressures, an Exhaust Filter is desirable.



The Welch Exhaust Filter simply screws into the exhaust port in place of the dust cap and effectively removes these oil vapors.

Oil droplets entrained in the discharge air are removed by the combined action of a two-stage filter element. One stage consists of multiple layers of fine wire screen and the other of a special non-organic fiber. Oil collected by these two components is drained from the element back through the discharge connection into the oil reservoir of the pump.

EXHAUST FILTERS

No. 1417. For Nos. 1399, 1400, 1405, 1406 and 1410 Pumps. 2″ Dia. X 4¾″ High, ¾-20 male thread. ..... **Each, $17.50**

No. 1417A. For Nos. 1402 and 1403 Pumps. 6″ Dia. X 7½″ High, 1-20 male thread ..... **Each, $30.00**

No. 1417B. For No. 1397 Pump. 7″ Dia. X 10″ High, 1¾-20 male thread. ..... **Each, $52.50**

REPLACEMENT FILTERS

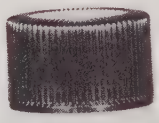
No. 1417F. For No. 1417 Filter. ..... **Each, $ 6.50**
No. 1417G. For No. 1417A Filter..... **Each, $12.00**
No. 1417H. For No. 1417B Filter. ..... **Each, $17.50**

SINCE 1880

WELCH *DUO-SEAL*® PUMP OIL

For All *Duo-Seal* Vacuum Pumps

WITH OUTSTANDING
Low Vapor Pressure
Chemical Stability
Ideal Viscosity



MADE UNDER A PATENTED PROCESS

Produced according to the most exacting specifications. Each batch must pass rigorous tests in our control laboratory before it can be released for use.

DUO - SEAL OIL IS SO DEPENDABLE THAT

The high vacuum performance guarantee of Welch Duo-Seal Pumps applies ONLY when Duo-Seal Oil is used. Repeated tests prove that Duo-Seal Pumps perform best with Duo-Seal Oil. There can be no substitute for high quality.

FOR BEST RESULTS —

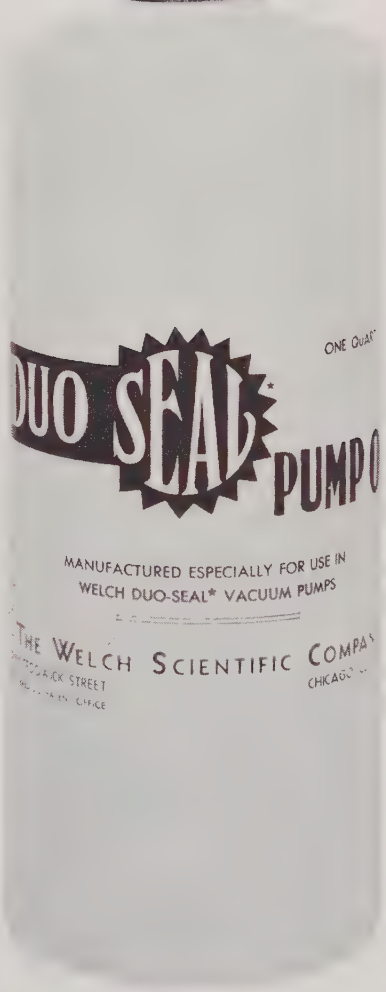
Whether you operate your Welch Duo-Seal Pump constantly or intermittently . . .

1. Check oil level periodically—
2. Inspect for contamination regularly—
3. Change oil when necessary—and—
4. Always use Welch Duo-Seal Pump Oil.

No. 1407K DUO - SEAL OIL, For Welch Mechanical Pumps. Best results can be expected when an oil of very low vapor pressure is used. This is the only oil recommended for use with Welch Duo-Seal Vacuum Pumps.

ORDER LARGER QUANTITIES AT A SAVING

Quart..$0.90	Gallon..$2.65	5-Gal. Drum..$10.85
12-Qt. Case..8.40	4-Gal. Case..9.00	55-Gal. Drum..79.75



No. 1407K.

SINCE 1880

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THE WELCH SCIENTIFIC COMPANY

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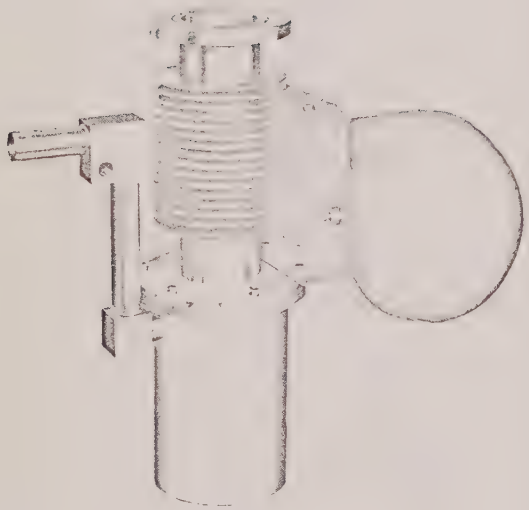
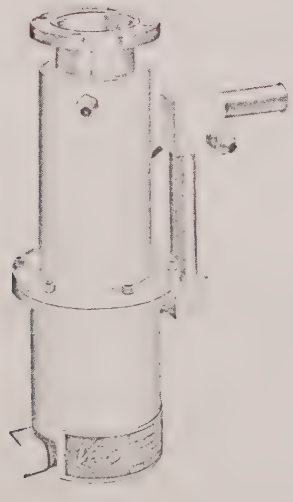
2" AIR-COOLED and WATER-COOLED DIFFUSION PUMPS

TYPE EP2AB
TYPE EP2W



Type EP2AB Air-Cooled Pump



Type EP2W Water-Cooled Pump

This three-stage fractionating pump combines excellent performance with compact dimensions. The scientific design results in the following characteristics:

FEATURES

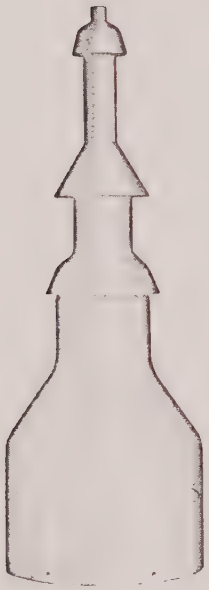
- High Speed—90 liters/sec.
- Low Ultimate Pressure.
- Low Backstreaming.
- High Forepressure Tolerance.

The speed is constant up to 0.1 microns. This speed is attained with backstreaming (at no load) of only .003 cc per hour. This excellent performance stems from precise jet design and large boiler area.

A unique feature contributing to the freedom from backstreaming is the full-flowing, unimpeded top jet. The ribs usually employed to support this jet, and which produce turbulence, have been eliminated. The retaining "spider," usually positioned on the top jet and interfering with gas flow, has also been eliminated. The jet stack screws onto a stud located on the bottom of the pump. The high limiting forepressure gives the pump some "booster" action, and large throughput. Since backstreaming and ultimate pressure (ultimate vacuum) are closely connected, the pump shows superior performance in this latter respect also. Comparative measurements on the *identical,* baked-out test system gave the results shown in the table on the following pages.

The boiler section of the pump, that is, the section below the lowest jet, has been made relatively long. The condensed oil flows back over this long, warm wall in a thin film. The heat tends to drive off high vapor-pressure components from the oil film, and the long path permits this action to take place for the maximum time. The forepump removes the vapors which distill off. A very efficient fractionating action is thus obtained.

TYPE EP2AB
TYPE EP2AW



Streamlined Jet Assembly,
showing absence of screw heads

The jet assembly, made of aluminum throughout, has no screw heads exposed to the vapor streams. This streamlining minimizes oil decomposition, since obstructions are focal points for tar formation.

The body of the pump consists of two sections—the boiler and the stack. The materials of construction for the body have been chosen for their chemical inertness and their heat conduction properties. The boiler walls are stainless steel tubing. In the air-cooled pump the stack is bar stock aluminum. None of these materials react with pump oil. The low thermal conductance of stainless steel keeps heat in the boiler and away from the stack. The high heat conductivity of aluminum assures uniform cooling of the stack and consequent efficient condensation of the oil vapor.

The water-cooled version of the EP2 has a cooling stack which is all-stainless steel, including the cooling jacket. This insures against corrosion both in the stack and in the jacket; the latter part might otherwise be corroded by the cooling water.

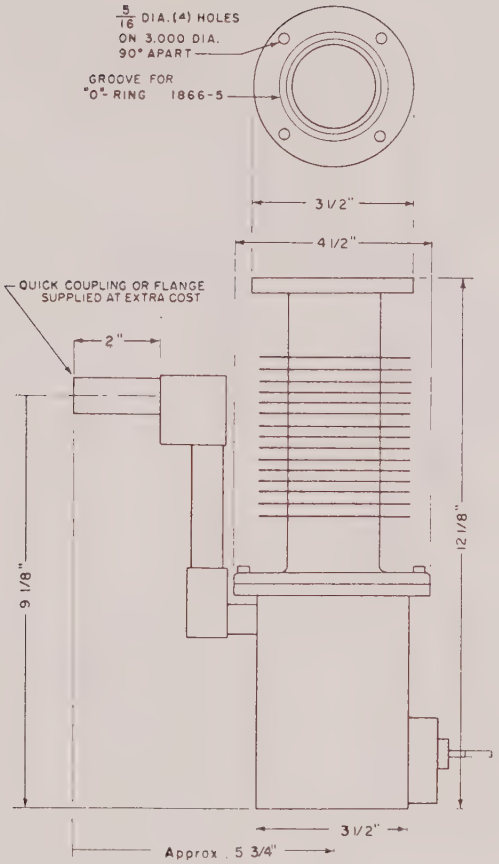
The pump may be easily disassembled, and the jets removed, by "dropping" the boiler section. The boiler is flanged to the stack and may be removed by loosening the six flange screws. The flange seal is made by a Teflon O-ring.

The water-cooled pump has similar performance to the air-cooled version. Major differences are somewhat higher pumping speed and less backstreaming (.001 cc/hr).

Note that the air-cooled pump can be obtained complete with mounted blower, as illustrated; also, that all pumps have a flanged inlet.

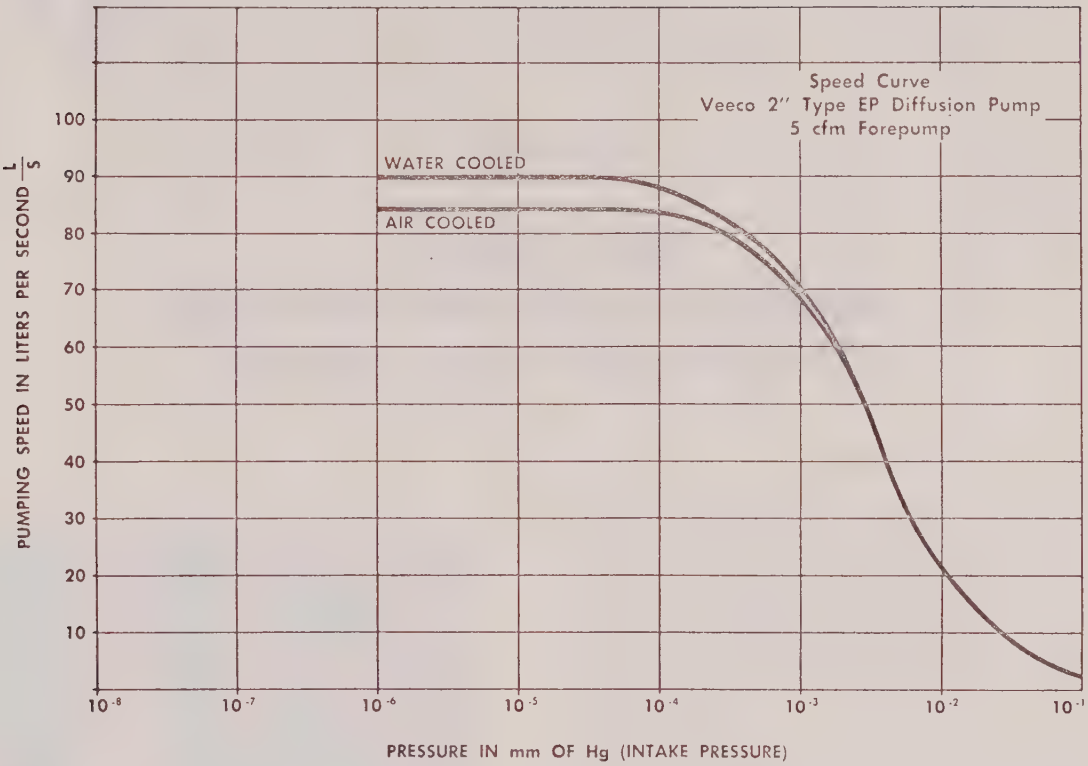
Electrical connection is by means of a standard plug, supplied with pump. Oil change is 60 cc.; DC-704 is the recommended fluid. Pump operates directly from 115 V AC lines. Power consumption is 350 watts.

An air switch is available for the air-cooled pump. The switch may be mounted in the stream, and actuates a relay on decrease, or failure, of air velocity. The relay may be used to shut off power to the diffusion pump.



Comparative Characteristics of 3 Commercial Diffusion Pumps

				Ultimate Vacuum mm Hg.	
Pump	Back Streaming at 25°C cc/hr.	Speed at 5×10^{-5} mm of Hg.	Limiting Forepressure Microns	Baked Gauge	Liquid N_2*
Veeco 2" Air-Cooled	.003	85 l/s	380	5×10^{-9}	2×10^{-9}
Pump "B" 60 l/s Water-Cooled	.012	55 l/s	380	1×10^{-7}	1.5×10^{-8}
Pump "C" 70 l/s Water-Cooled	.003	65 l/s	200	2×10^{-8}	9×10^{-9}
*Gauge Trapped with Liquid Nitrogen					



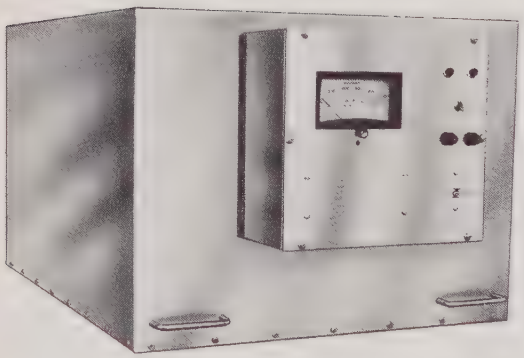
Cat. No.	
EP2AB:	2" Three-Stage Pump with flange*, air-cooled, complete with mounted blower.
EP2A:	2" Three-Stage Pump with flange*, air-cooled.
Z156:	Air Blower for EP2A.
RT2A:	Air Safety Switch for blower.
EP2W:	2" Three-Stage Pump with flange*, water-cooled.
EP2BF:	Flange, brass, blank, for matching high-vacuum flange on Type EP2 Pumps, with nuts and bolts.
EP2-CO:	Oil Charge (Veecoil I) for Type EP2 Pumps.
EP12-1-9:	Teflon Gasket for boiler of Type EP2 Pumps.

*All pumps supplied with flange gasket.

Granville-Phillips Company
5675 East Arapahoe Avenue • Boulder, Colorado 80302, USA
Area Code 303 443-7660

SERIES 253

BAKEOUT OVEN
FOR ULTRA-HIGH VACUUM SYSTEMS
INSTALLATION AND OPERATING INSTRUCTIONS



DESCRIPTION

The Granville-Phillips Series 253 Bakeout Oven is a simple, inexpensive portable bakeout oven for use up to 450°C. The oven is of all stainless steel construction with glass fiber insulation. The heating element is of the open type with minimal thermal mass for rapid temperature cycling.

The oven and controller weighs less than 75 pounds so that it may be readily placed on or removed from a system without the use of hoists.

UNCRATING INSTRUCTIONS

The following instructions are also stapled to the outside of the oven shipping crate.

Release the latches on the top of the shipping crate and carefully lift out the oven. Replace the top and return the crate to Granville-Phillips Company. Your organization can save $50.00 by returning the shipping crate to us via motor freight collect within 30 days. An envelope containing return labels is stapled to the inside of the top of the crate for your convenience.

OPERATING INSTRUCTIONS

CAUTION: Dangerous voltages are present on the heating element mounted inside the top of the oven when the oven is plugged in. Do not touch the element or permit apparatus to come in contact with the element.

1. The bakeout oven is made entirely of polished stainless steel and insulated with mineral insulation.
2. The heater wattage has been chosen to provide 450°C Temperatures when the oven is resting on the insulated system top or other suitable insulated support.
3. Plug the unit into 208-220V, 60 CPS, 15 Amp power. A mating receptacle is included for your convenience. **IMPORTANT:** Refer to Figure 1 for proper "hookup" of this receptacle.
4. Your oven has only one switch which controls the power into the unit. The "Power" light will be on whenever power is applied to the unit. The "Heater" light will be lighted when the heating element is functioning.
5. The desired temperature is set merely by turning the knob below the temperature indicating dial. Once the temperature is set, it will automatically be maintained without further attention. Additional detailed instructions for the A.P.I. temperature indicating controller are attached.
6. Two 15 Amp fuses for overload protection have been placed on the control panel for easy replacement.
7. Handles are located at each end for placing the oven over the zone to be baked. To avoid burns, wait until the oven has cooled to about 200°C or use protective insulation over the handles before removing the oven.

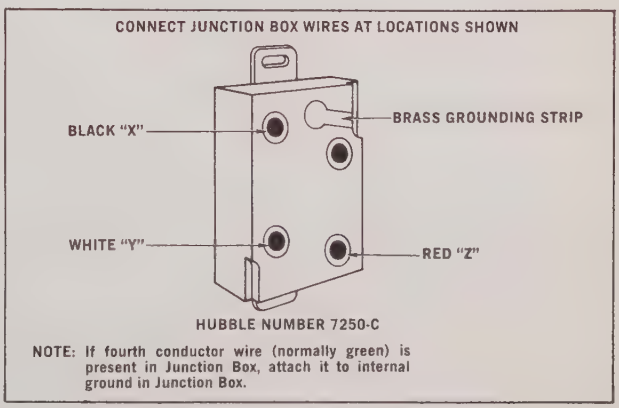

CONNECT JUNCTION BOX WIRES AT LOCATIONS SHOWN
BLACK "X"
BRASS GROUNDING STRIP
WHITE "Y"
RED "Z"
HUBBLE NUMBER 7250-C
NOTE: If fourth conductor wire (normally green) is present in Junction Box, attach it to internal ground in Junction Box.

Figure 1. Receptacle installation illustration.

SPECIFICATIONS

Power ..... 2600 Watts, 208-220 Volt Single Phase

Temperature range ..... Ambient to 450° when resting on insulated work top.

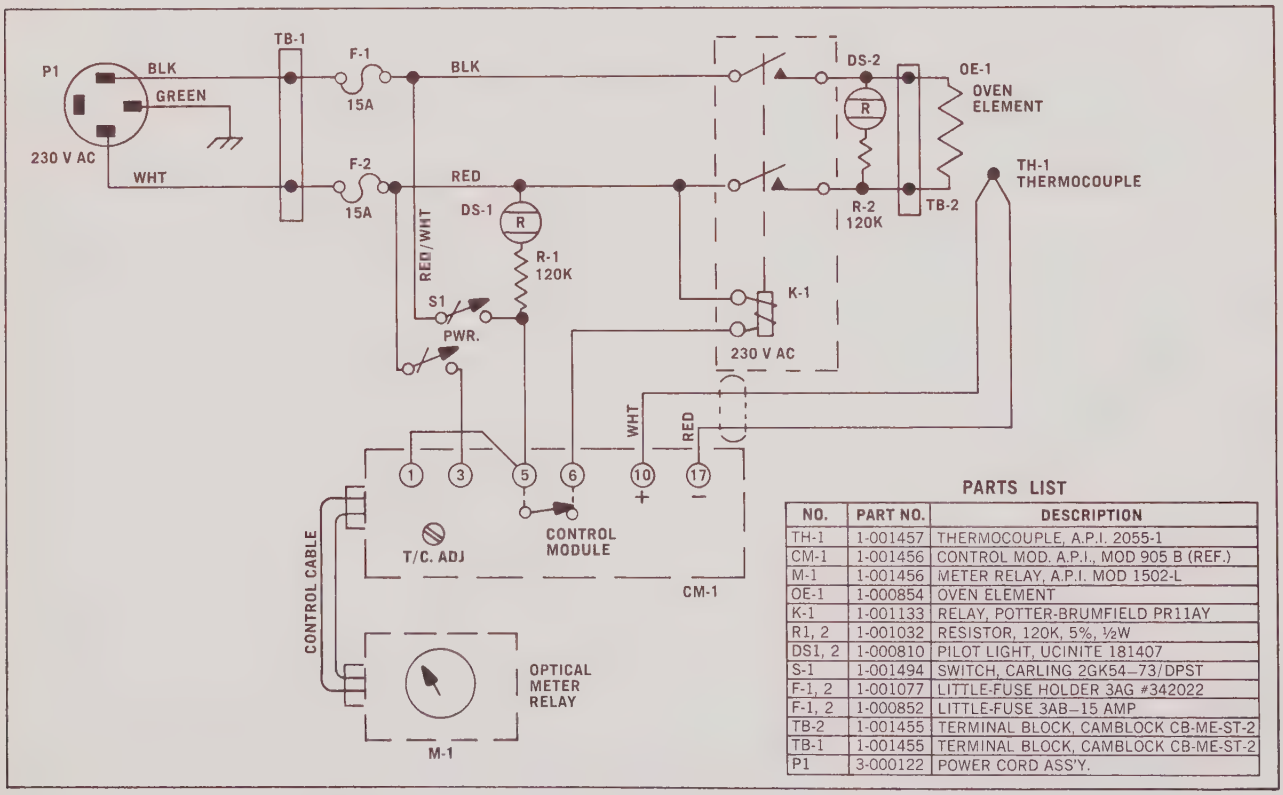
Useable inside height ..... 15 Inches

Useable inside width ..... 21 Inches

Useable inside length ..... 27 Inches

TROUBLE SHOOTING

SYMPTOM	CAUSE	REMEDY
Bakeout oven controller out of calibration.	Adjustment has slipped or been changed.	Check per A.P.I. Instructions enclosed.
Temperature overshoots by a few degrees.	Normal condition.	
Oven does not heat.	Fuses blown. No power. Heater burned out.	Check fuses on front panel. Check power source. Unplug and check for continuity with ohmmeter.



PARTS LIST

NO.	PART NO.	DESCRIPTION
TH-1	1-001457	THERMOCOUPLE, A.P.I. 2055-1
CM-1	1-001456	CONTROL MOD. A.P.I., MOD 905 B (REF.)
M-1	1-001456	METER RELAY, A.P.I. MOD 1502-L
OE-1	1-000854	OVEN ELEMENT
K-1	1-001133	RELAY, POTTER-BRUMFIELD PR11AY
R1, 2	1-001032	RESISTOR, 120K, 5%, ½W
DS1, 2	1-000810	PILOT LIGHT, UCINITE 181407
S-1	1-001494	SWITCH, CARLING 2GK54–73/DPST
F-1, 2	1-001077	LITTLE-FUSE HOLDER 3AG #342022
F-1, 2	1-000852	LITTLE-FUSE 3AB–15 AMP
TB-2	1-001455	TERMINAL BLOCK, CAMBLOCK CB-ME-ST-2
TB-1	1-001455	TERMINAL BLOCK, CAMBLOCK CB-ME-ST-2
P1	3-000122	POWER CORD ASS'Y.

Figure 2. Series 253 Bakeout Oven schematic diagram and parts list.

WARRANTY

Granville-Phillips Company warrants that each item of merchandise sold by it is free from defective workmanship or material and it will replace or repair any item found to be defective in workmanship or material upon return of the same to the Granville-Phillips office at Boulder, Colorado, U.S.A. The liabilities of Granville-Phillips arising out of the supplying of said products or their use, whether on said warranties or otherwise, shall in no case exceed the cost of correcting defects in the product. No other warranty, expressed or implied, is assumed or will be assumed.

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ATTACHMENTS: A.P.I. Instructions and Schematic No. 2786-28

GRANVILLE-PHILLIPS COMPANY

VACUUM EQUIPMENT

FOR USE FROM ATMOSPHERIC
TO THE
LOWEST PRESSURES ATTAINABLE

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PHONE 303/443-7660 • TELEX 045-791

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Area Code 303 443-7660

OPERATING INSTRUCTIONS
For
Series 236 Model 02
IONIZATION GAUGE CONTROLLER

Your Granville-Phillips Series 236 Ionization Gauge Controller has many unusual features and capabilities not available in other controllers. We invite (and urge) you to get the most out of your investment by taking time to thoroughly understand the operating principles and instructions. It has been our experience that a high percentage of the problems encountered with complex electronic equipment are a result of inadequate use of the necessary operating information.

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OPERATING INSTRUCTIONS

WARNING

WHENEVER THE CONTROLLER IS TURNED ON, DANGEROUS VOLTAGES ARE PRESENT INSIDE THE CONTROLLER AND AT THE GAUGE AND COLLECTOR PLUGS. DO NOT TOUCH THE GAUGE OR COLLECTOR LEAD TERMINATIONS WHEN THE POWER IS TURNED ON. LETHAL VOLTAGES ARE PRESENT AT THESE CONNECTIONS WHEN THE CONTROLLER FUNCTION SWITCH IS SET AT ANY DEGAS POWER SETTING.
This controller is designed for use at ambient temperatures up to 50°C. (122°F). Operation at temperatures greater than 50°C can cause damage to the controller.

1.0 INTRODUCTION TO INSTRUMENT

The Series 236 Ionization Gauge Controller was designed to give the operator full control over all important variables. It may also be operated simply like other controllers—turn it on and ignore the finer details of pressure measurement. Figures 1 and 2 show the nomenclature and location of controls.

This Controller is intended for use with most commercially available Bayard-Alpert type ionization gauge tubes or with most standard triode type gauges.

The Controller causes the gauge tube filament to emit an accurately known current of electrons. When some of these electrons collide with gas molecules in the tube, ions are formed and a fraction of these ions are collected by the collector electrode. This small ion current is amplified and displayed on the panel meter as a measure of the gas density in the tube. At constant temperature the density is directly proportional to the pressure in the tube.

This common method of measuring low pressures is deceptively simple in principle: the positive ion current to the ion collector is a direct measure of the gas density in the gauge, assuming all other variables remain fixed.

Here it must also be assumed that ions arise only because of collision of electrons with molecules in the gas phase and that the collector current consists only of a positive ion component. It is useful to examine in detail the assumption that all other variables remain fixed. The positive ion current to the ion collector is directly dependent on at least seven variables. These variables are electron collector grid current, gas density, gas composition or type, electron path length, electron energy, ion collection efficiency, and electron collection efficiency.

The Series 236 Controller is designed to accurately control the electron collector grid current, as are all good controllers. However, the other six variables may change uncontrollably unless certain precautions are taken to avoid changes. Your new Controller was specially designed to assist you in reducing or eliminating unwanted changes in gauge tube operation.

The gas density may change in the gauge from that in the remainder of the system because of the pumping action of the gauge and outgassing produced by the hot filament. By using the emission current controls judiciously one can reduce the pumping action and also decrease outgassing. By using the controlled power electron bombardment degassing feature, outgassing can be reduced to negligible amounts.

The gas composition may change because of difference in gauge pumping speed for various gases, because of outgassing, because of gas exchange, or because of permeation. Here again reduced emission and thorough degassing will help to minimize these changes.

Electron paths in the gauge tube may change if the electron accelerating potential changes, if wall potentials change, if insulating films on the electrodes charge up, or if the gas density changes. The Series 236 Controller provides an accurately controlled electron accelerating potential. Unlike some controllers it does not automatically switch emission current as the pressure changes—a common cause of wall potential changes.

The electron energy at any point in the gauge may change because of changes in wall potentials, ion or electron space charge build-up, gas density or composition changes, or Barkhausen oscillations. Ion and electron collection efficiencies are dependent on wall potentials, space charge, and gas density.
Your new Controller contains numerous features to assist you in making accurate pressure measurements. These features are described fully on the following pages.

2.0 INSTALLATION

2.1 CHECK OF THE GAUGE TUBE CABLE

The gauge cable supplied with your Model 02 Controller is wired as shown in Figure 3A for use with standard in-line .250" spacing ion gauge tube leads as furnished by a number of gauge tube manufacturers. Check to see that your gauge tube conforms to this arrangement before plugging in for the first time. If it does not, rewire the connector. Note that only terminal "H" is wired for grid connection as the cable is manufactured. If your gauge tube has only one grid lead, connect terminal "A" to terminal "H" so that connection is made to the grid regardless of how the connector is placed on the tube.
Note that the power to the filament is controlled by the amount of emission current flowing in the grid circuit. If the grid is not properly connected or is inadvertently disconnected, the filament control circuit will be operating open loop and may burn out the filament.

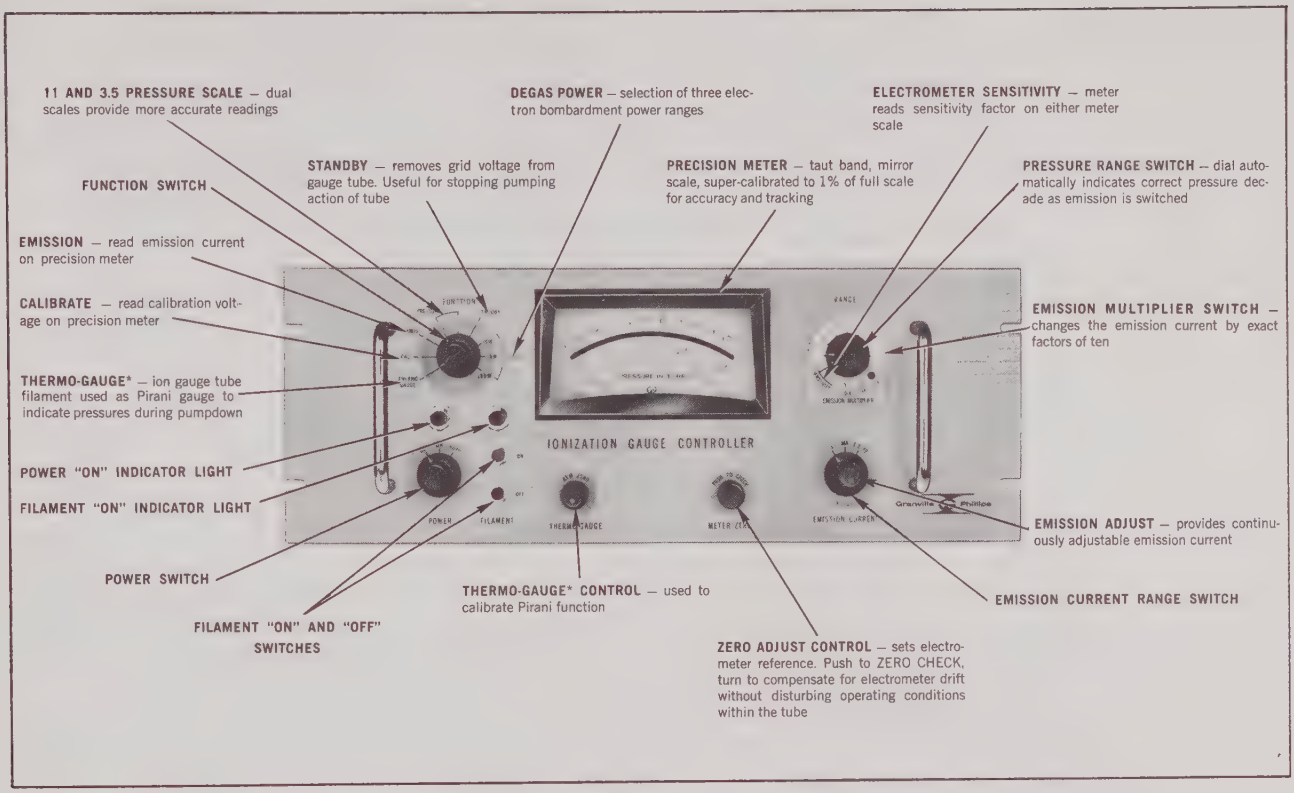
11 AND 3.5 PRESSURE SCALE — dual scales provide more accurate readings
DEGAS POWER — selection of three electron bombardment power ranges
ELECTROMETER SENSITIVITY — meter reads sensitivity factor on either meter scale
STANDBY — removes grid voltage from gauge tube. Useful for stopping pumping action of tube
PRECISION METER — taut band, mirror scale, super-calibrated to 1% of full scale for accuracy and tracking
PRESSURE RANGE SWITCH — dial automatically indicates correct pressure decade as emission is switched
FUNCTION SWITCH
EMISSION — read emission current on precision meter
CALIBRATE — read calibration voltage on precision meter
THERMO-GAUGE* — ion gauge tube filament used as Pirani gauge to indicate pressures during pumpdown
EMISSION MULTIPLIER SWITCH — changes the emission current by exact factors of ten
IONIZATION GAUGE CONTROLLER
POWER "ON" INDICATOR LIGHT
FILAMENT "ON" INDICATOR LIGHT
EMISSION ADJUST — provides continuously adjustable emission current
POWER SWITCH
THERMO-GAUGE* CONTROL — used to calibrate Pirani function
EMISSION CURRENT RANGE SWITCH
FILAMENT "ON" AND "OFF" SWITCHES
ZERO ADJUST CONTROL — sets electrometer reference. Push to ZERO CHECK, turn to compensate for electrometer drift without disturbing operating conditions within the tube

Figure 1. Controls on Ionization Gauge Controller front panel.

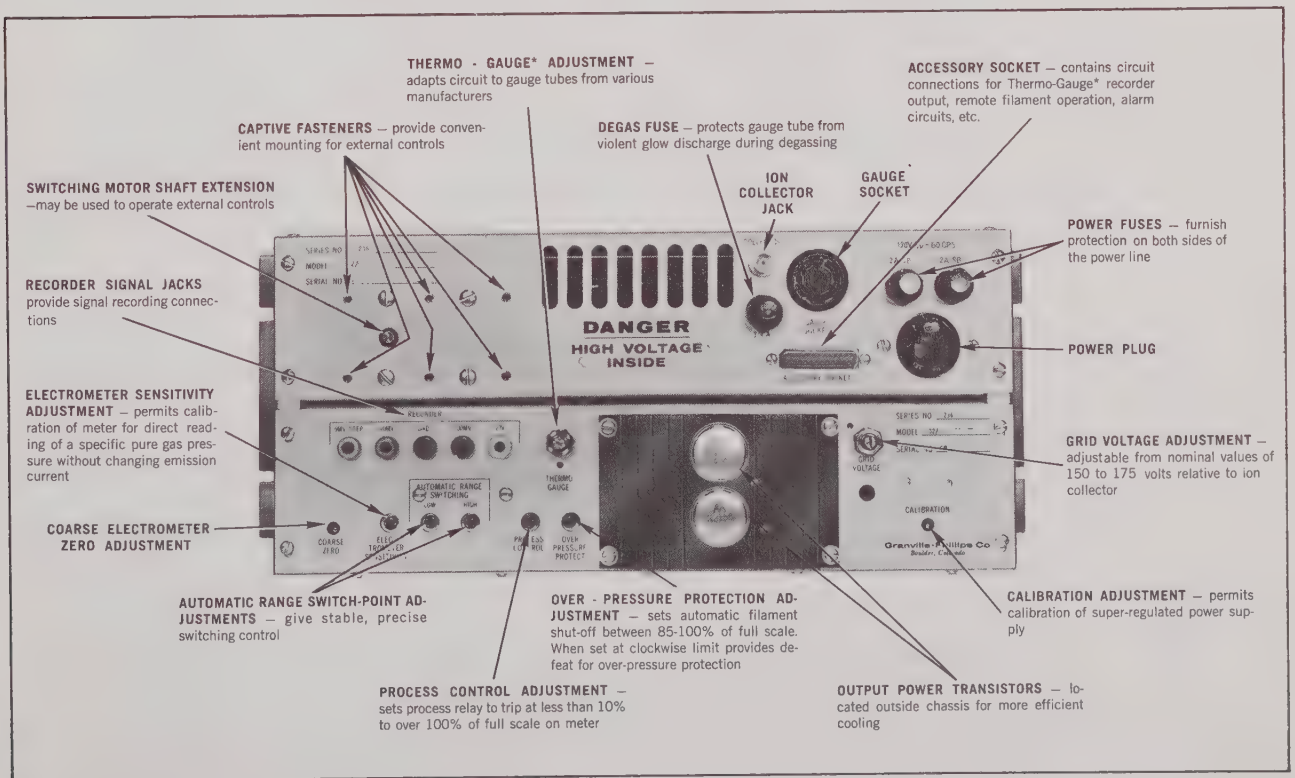
THERMO - GAUGE* ADJUSTMENT — adapts circuit to gauge tubes from various manufacturers
ACCESSORY SOCKET — contains circuit connections for Thermo-Gauge* recorder output, remote filament operation, alarm circuits, etc.
CAPTIVE FASTENERS — provide convenient mounting for external controls
DEGAS FUSE — protects gauge tube from violent glow discharge during degassing
ION COLLECTOR JACK
GAUGE SOCKET
SWITCHING MOTOR SHAFT EXTENSION —may be used to operate external controls
POWER FUSES — furnish protection on both sides of the power line
DANGER
HIGH VOLTAGE INSIDE
RECORDER SIGNAL JACKS provide signal recording connections
POWER PLUG
ELECTROMETER SENSITIVITY ADJUSTMENT — permits calibration of meter for direct reading of a specific pure gas pressure without changing emission current
GRID VOLTAGE ADJUSTMENT — adjustable from nominal values of 150 to 175 volts relative to ion collector
COARSE ELECTROMETER ZERO ADJUSTMENT
AUTOMATIC RANGE SWITCH-POINT ADJUSTMENTS — give stable, precise switching control
OVER - PRESSURE PROTECTION ADJUSTMENT — sets automatic filament shut-off between 85-100% of full scale. When set at clockwise limit provides defeat for over-pressure protection
CALIBRATION ADJUSTMENT — permits calibration of super-regulated power supply
PROCESS CONTROL ADJUSTMENT — sets process relay to trip at less than 10% to over 100% of full scale on meter
OUTPUT POWER TRANSISTORS — located outside chassis for more efficient cooling

Figure 2. Controls on Ionization Gauge Controller rear panel.

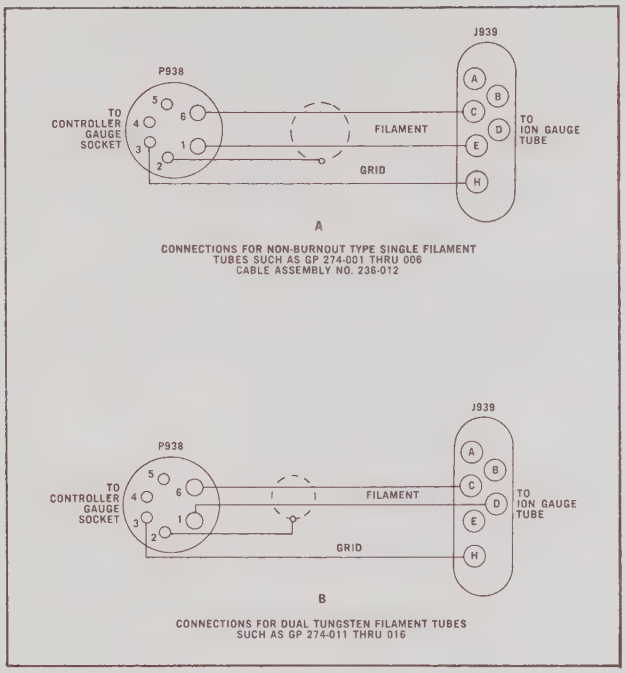

Figure 3. Gauge tube connections.

2.2. CONNECTIONS TO THE CONTROLLER

Before connecting the Controller to the power mains check the following:

CHECK LIST

EQUIPMENT OR CONTROLS	PROPER POSITION
Circuit board	In place.
Top and bottom panels	In place. Never operate unit with these panels off. Dangerously high voltages exist inside and at the gauge and collector terminals.
Front Panel	POWER switch OFF. FUNCTION switch at STANDBY. EMISSION MULTIPLIER to .1X.
Meter	Check the mechanical zero. Adjust the screw in the base of the meter face if zero is off.
Gauge Cable	Connect the in line connector firmly to the gauge tube. Insert the six-pin plug into the GAUGE SOCKET. Use raised dot on plug and socket to help determine the correct orientation.
Collector Cable	Attach BNC connector to COLLECTOR jack. Clip miniature alligator type connector to gauge tube collector lead.
Power Cable	Check to see that the available power line frequency and voltage coincide with that marked on the rear panel. This unit will NOT operate on direct current. If the supply is correct, plug the power cord into the mains. Be certain that the unit is properly grounded via the ground pin on the line cord. Never operate the unit ungrounded. See Figure 6 for changing power requirements from 105-125 to 210-250 VAC.

3.0 DETAILED OPERATION PROCEDURES

WARNING

WHENEVER THE CONTROLLER IS TURNED ON, DANGEROUS VOLTAGES ARE PRESENT INSIDE THE CONTROLLER AND MAY BE PRESENT AT THE GAUGE AND CONTROLLER PLUGS. DO NOT TOUCH GAUGE OR COLLECTOR LEAD TERMINATIONS WHEN THE POWER IS TURNED ON. LETHTAL VOLTAGES ARE PRESENT AT THESE CONNECTIONS WHEN THE CONTROLLER FUNCTION SWITCH IS SET AT ANY DEGAS POWER SETTING.

Note: This instrument has a number of interlocks and safety devices which prevent improper operation. Thus, if there is no response to some step in the instructions, check carefully to see that all controls are in their proper positions before attempting any adjustment.

3.1 IONIZATION GAUGE PRESSURE MEASUREMENT

3.1.1 Calibration Check

.1. Follow all procedures in Section 2.2 above.

.2. Turn POWER switch to ON. The indicator light above the POWER switch should come on.

.3. Turn the FUNCTION switch to CAL. The meter should read 10.0 on the black scale. Slight deviations from 10.0 should be corrected by adjusting the CALIBRATION adjustment on the rear panel. This adjustment provides the correct power supply voltage for several sensitive circuits, and occasional checks should be made to insure this proper operating voltage.

3.1.2 Setting the Electrometer Zero

.1 Turn the FUNCTION Switch to the 11 position, and the RANGE switch to 10^{-5} position. The filament should be OFF.

.2. Turn the METER ZERO adjustment knob until the meter indicates zero. See Section 4.2.1.1 for more details concerning precise setting of the electrometer zero.

3.1.3 Electrometer Sensitivity Check

.1. Set the electrometer zero as per Section 3.1.2.

.2. Turn the RANGE switch to SENSITIVITY position.

.3. Turn the FUNCTION switch to 3.5 position. The meter now indicates the electrometer sensitivity on the blue 0-3.5 scale. The lowest possible value (approximately 2.0) is the correct sensitivity for use with the typical gauge tube which has a sensitivity of 10/torr. For gauge tube sensitivity check the tube manufacturer's specifications.

See Section 4.2.2 for information on the choice of electrometer sensitivity settings. Electrometer sensitivity adjustment is made via the ELECTROMETER SENSITIVITY control on the rear panel. **Note:** METER ZERO must be properly adjusted prior to reading or adjusting electrometer sensitivity.

3.1.4 Starting the Filament

.1. **Danger:** The gauge tube can be damaged by turning the filament on when the pressure is greater than 10^{-3} torr.

.2. When operating the Controller for the first time, or in a system of unknown pressure set the emission current controls such that the overpressure protection can be effective, namely:

EMISSION MULTIPLIER—.1X
EMISSION CURRENT MA—3.2-10
EMISSION CURRENT ADJUST—Clockwise limit

.3. Turn the RANGE switch to the 10^{-4} position.

.4. If the pressure is known to be sufficiently low, depress the FILAMENT ON button. If the tube is new, or has been contaminated, it may be necessary to depress the FILAMENT ON button several times before the filament will remain on. If the pressure is in the operating range of the tube, the filament will remain on, there will be no bluish glow discharge,

and the meter will read below full scale. **Note:** The filament cannot be turned on when the FUNCTION switch is in either CALIBRATE or STANDBY positions, or when the RANGE switch is in the SENSITIVITY position.

.5. If the filament stops glowing, but the FILAMENT ON light continues to burn, either the connection thru the filament has opened, or the ¼ ampere fuse has burned out. This fuse protects the tube and controller from damage in cases of severe discharge. Replace it with ¼ ampere standard fuse. DO NOT USE A SLO-BLO TYPE. It is important that the grid and filament connections be kept clean and conductive.

3.1.5 Establishing the Correct Emission Current

.1. Check the recommended emission current for the gauge tube in use.

EMISSION CURRENT RANGE	EMISSION CURRENT MA SWITCH	EMISSION MULTIPLIER SWITCH	METER SCALE
10-3.2 ma	3.2-10	1X	0-11
3.2-1.0 ma	1-3.2	1X	0-3.5
1.0 ma-320 ua	3.2-10	.1X	0-11
320 ua-100 ua	1-3.2	.1X	0-3.5
100 ua-32 ua	3.2-10	.01X	0-11
32 ua-10 ua	1-3.2	.01X	0-11

Table 1. Emission current control settings.

.2. Turn the FUNCTION switch to EMIS. The emission current may be read on the meter when the FUNCTION switch is in the EMIS position, and the filament is on. The meter shunts are switched with the emission current such that the reading is always on scale. When the EMISSION CURRENT switch is in the blue 1-3.2 position the emission current is read on the blue scale of the meter except for the .01 EMISSION MULTIPLIER position. All emission currents of 100 microamperes and less are read on the 0-11 scale.

.3. Set the exact desired emission current. For emission currents between .1 and 3.2 ma, use the 1-3.2 setting of the EMISSION CURRENT switch. For emission currents greater than 3.2 milliamperes, use the 3.2-10 setting. The red EMISSION CURRENT ADJUST control provides adjustment within the EMISSION CURRENT switch ranges. The EMISSION MULTIPLIER multiplies any emission current from 1 ma to 10 ma by .01X, .1X or 1X, making it possible to cover the range from 10 ua to 10 ma. See Table 1.

.4. Turn the FUNCTION switch to the 3.5 or 11 pressure position.

3.1.6 Reading the Pressure

.1. Turn the RANGE switch to the proper pressure range to give the largest possible on scale meter reading. Use the FUNCTION switch in the 3.5 or 11 position as required to give the largest meter deflection.

.2. The meter zero may be checked (POWER switch in ON position, and FUNCTION switch in 3.5 or 11 position) either by turning off the filaments or by pushing the METER ZERO control. When making measurements at pressures below 10^{-8} torr, use the METER ZERO-PUSH TO CHECK feature with the filament operating to obtain the most accurate meter zero indication. Note that this electrical adjustment of meter zero applies only to the 3.5 and 11 pressure scales of the FUNCTION switch. Use care not to inadvertently rotate the METER ZERO control.

3.1.7 Automatic Range Switching. (Not applicable on manual range changing units where the POWER switch is locked out of AUTO position).

.1. After the instrument is reading pressure correctly with the POWER switch in the ON position, the POWER switch may be set on AUTO. The Controller will now automatically change ranges so that the meter will always be on scale.

.2. Note that if the METER ZERO control is depressed while the unit is on AUTO, the range changing motor will turn toward lower pressures.

3.2 THERMO GAUGE CALIBRATION

Before the THERMO GAUGE feature can be used, the Controller must be calibrated for the gauge tube in use. Do not attempt to calibrate the Controller immediately after using the tube as an ion gauge. Wait 30 minutes for the tube to cool.

3.2.1 Setting the ATM Control

.1. Turn the POWER switch to ON

.2. Set the FUNCTION switch to THERMO GAUGE

.3. Depress the filament ON button

.4. With the system and gauge tube at atmospheric pressure, adjust the black Thermo Gauge ATM control until the meter reads within the area labeled ATMOS on the bottom scale. Do not disturb this adjustment.

3.2.2 Setting the ZERO Control

.1. Pump the system down below 1 x 10^{-4} torr and adjust the red Thermo Gauge ZERO control until meter reads zero on the bottom meter scale. The Thermo Gauge is now ready to indicate the approximate pressure whenever the FUNCTION switch is in the THERMO GAUGE position and the filament is ON.

.2. Should the filament glow slightly under vacuum when using the THERMO GAUGE feature, refer to section 4.2.6.

3.3 DEGASSING THE GAUGE TUBE

3.3.1 **Warning:** FOR SAFETY SAKE DO NOT LEAVE THE FUNCTION SWITCH IN THE DEGAS POSITIONS WHEN NOT ACTUALLY DEGASSING A GAUGE TUBE. WHEN THE FUNCTION SWITCH IS IN ANY DEGAS POSITION THERE ARE LETHAL VOLTAGES AT THE GRID AND COLLECTOR CONNECTIONS.

3.3.2 Procedure

.1. Turn the filament OFF. If the pressure is below about 10^{-5} torr, turn the FUNCTION switch to the 30W (watt) DEGAS position. Note that there is little to be gained by degassing at pressure greater than 10^{-5} torr.

.2. To degas the gauge tube for the first time, reduce the emission to its lowest possible value by turning the red EMISSION CURRENT ADJUST control to its counterclockwise limit. On subsequent gauge bake-outs it will probably not be necessary to perform this step unless the tube is known to be very dirty. During degassing operations the power applied to the tube is indicated on the black 0-11 meter scale. Multiply the meter reading by 10 to obtain the power in watts.

.3. Depress the FILAMENT ON button. Watch for a bluish glow discharge which is an indication that the pressure is too high.

.4. If a blue glow appears, continue pumping until it disappears, then gradually increase the electron bombarding power by turning the red EMISSION ADJUST knob clockwise until the meter reads 3, indicating 30 watts. Caution: Do not use more power than recommended by the manufacturer of your gauge tube. If the filament stops glowing, but the FILAMENT ON light continues to burn, either the connection through the filament has opened, or the ¼ ampere fuse has burned out. The ¼ ampere fuse protects the tube and controller from damage in cases of severe discharge. Replace it with ¼ ampere standard fuse. DO NOT USE A SLO-BLO TYPE. It is important that the grid and filament connections be kept clean and conductive.

.5. After a few minutes, turn the FUNCTION switch to 60W (watts). **CAUTION**: Certain manufacturers' tubes may be damaged by high bakeout power.

.6. After a few minutes, turn the FUNCTION switch to 100W (watts). Leave in this position for 10 to 30 minutes, or as long as required. **CAUTION**: Some manufacturers' tubes may not be capable of producing sufficient emission to give 100 watts bombardment power. If filament becomes white hot, reduce power such that the normal bright orange temperature is restored.

.7. Turn the FUNCTION switch to 30W (watts) and degas at this power for a few minutes to remove the glass decomposition products from the tube.[1]

.8. Turn the filament OFF, and rotate the FUNCTION switch out of the DEGAS positions.

4.0 OPERATING INFORMATION

This section contains information on a number of Controller features not yet described, as well as those already mentioned which are required to use this Controller to its maximum potential.

4.1 EMISSION CURRENT

4.1.1 Emission Current Circuit. The Controller furnishes filament power to the gauge tube and regulates the emission current. Figure 4 shows the Ionization Gauge Controller in block form. The filament current (shown as a cross hatched line) is controlled by a high-gain, negative feedback amplifier such that the emission current is maintained at precisely the desired value. This filament control amplifier amplifies the difference in voltage between the IR drop across the current sensing resistor and the reference voltage obtained by setting the EMISSION ADJUST control. This amplified signal drives the filament control amplifier which regulates the current to the filament. The input voltage levels range from 2.5 volts to 7.5 volts, depending upon the setting of the EMISSION ADJUST CONTROL.

4.1.2 Choice of Emission Current. Emission current from 10 ua to 10 ma is available with the Series 236 Controller so that the optimum current can be used for any given measurement.

The emission current determines the amount of ion current available at any pressure, it influences the amount of pumping action in the gauge, and because emission depends directly on filament temperature and power, it influences the outgassing of the tube.

At very low pressures, too small an emission current may give so little ion current that measurement of the ion current becomes difficult.

4.1.3 Setting Emission Current. Electron emission current is controlled by an EMISSION CURRENT switch which determines the range of current available, by an EMISSION ADJUST control which provides continuous adjustment within a given range and by an EMISSION MULTIPLIER which accurately multiplies the set emission current by factors of .01, 0.1 or 1. When the FUNCTION switch is turned to EMIS, the meter reads the emission current on the scale corresponding to the EMISSION CURRENT MA position with 10 ma corresponding to 10 on the meter when the EMISSION MULTIPLIER is set at 1X. See Table 1.

.1. **Example**: How to set 10 ma emission. Switch the EMISSION CURRENT switch to the 3.2-10 position, turn the EMISSION ADJUST counterclockwise and set the EMISSION MULTIPLIER to 1X and the FUNCTION switch to EMIS. Push the FILAMENT ON button. Now turn the EMISSION ADJUST clockwise until the meter reads 10 on the black scale. The emission current is now 10 ma. 1 ma would be set in the same way except that the EMISSION MULTIPLIER would have been set at .1X. Note that the meter sensitivity is automatically switched so that

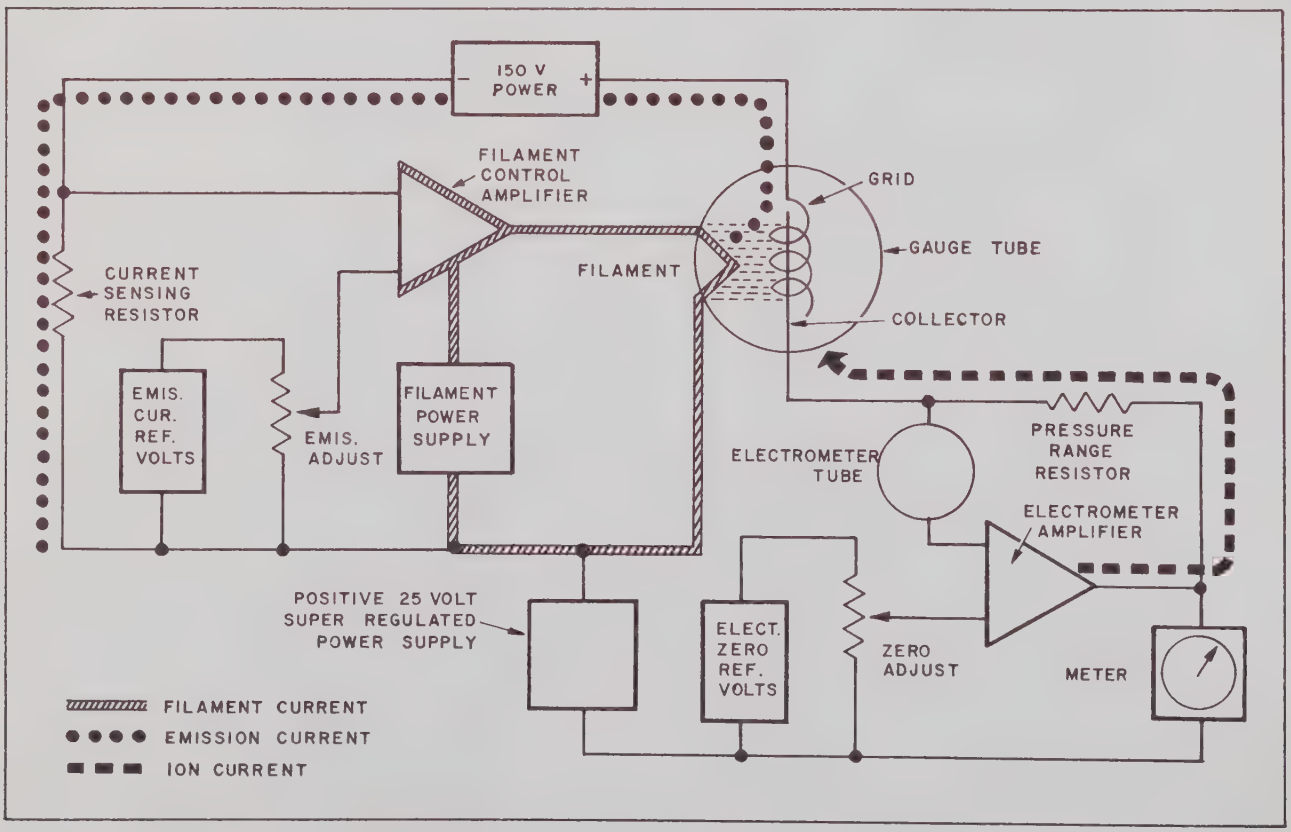

Figure 4. Ionization Gauge Controller block schematic diagram.

1) D. R. Denison, Rev. Sci. Inst. **10**, 1115 (1962)

the meter has the most accurate range for the current being measured, the only exception being for current below 32 microamperes. Because the meter has a 110 microampere movement, it is not possible to obtain a full scale reading of 32 microamperes. **The 0-11 meter scale is used for all emission currents of 100 microamperes and less.**

.2. **Example:** How to set 20 microamperes emission. Switch the EMISSION CURRENT MA switch to the 1-3.2 position. Turn the EMISSION ADJUST knob counterclockwise. Set the EMISSION MULTIPLIER to the .01X position and the FUNCTION switch to EMIS. Depress the filament ON button and turn the EMISSION ADJUST knob until the meter reads 2.0 on the black scale. The emission is now .01 x 2.0 ma = 20ua.

4.1.4 Checking Emission Current. The emission current being used can be checked at any time while the tube is being used to measure pressure by turning the FUNCTION switch to EMIS. This does not disturb potentials in the tube. The recorder signals and the automatic range Switching circuit continue to operate as though the FUNCTION switch were in the 11 position.

4.1.5 Emission Limit Potentiometer. The value of the emission current obtained when the EMISSION CURRENT ADJUST is turned to its clockwise limit is adjusted by an internal potentiometer R-1437 which may be reached only by removing the bottom cover to the controller. This potentiometer is adjusted with a screwdriver via the ¼ inch diameter hole in the circuit board. This control is factory set to give an emission current limit slightly greater than 10 on the 11 scale. If it becomes desirable to reset this control, use great caution because lethal voltages are exposed when the cover is removed.

4.2 PRESSURE MEASUREMENT

4.2.1 Electrometer Circuit. A high gain negative-feedback type amplifier is used so that the collector can be maintained at within a millivolt of ground, and so that accuracy of the readout is maintained. See Figure 4. An electrometer tube is interposed between the collector and the input of the electrometer amplifier so that virtually all of the collector current must flow through the pressure range resistor. An output voltage from the electrometer amplifier of $E_{output} = I_{collector} \times R_{range}$ is required to force the collector current through the pressure range resistor while maintaining the collector at ground potential. This voltage is an accurate measure of the collector current, and thus of the pressure. The output of the electrometer amplifier is very low impedance so that current drawn by the meter does not influence the accuracy of the measurement.

.1. Checking the Zero. The zero of the electrometer circuit may be checked by depressing the METER ZERO control on the front panel with the POWER switch in the ON position and the FUNCTION switch in the 3.5 or 11 position. Note that if METER ZERO is depressed while the POWER switch is in AUTO or automatic range switching position, the stepping motor will drive down scale.

If the meter does not indicate zero after a ½ hour warmup, depress the METER ZERO control and turn knob until it does. The zero may be set more accurately by turning the RANGE switch to a more sensitive scale with the METER ZERO control depressed. Be sure to return the RANGE switch to the correct setting before releasing METER ZERO. Should the range of the METER ZERO control be inadequate to make correct compensation, adjust the COARSE ZERO control on the rear panel.

4.2.2 Methods of Calibrating the Controller.
The pressure reading obtained from an ionization gauge controller can be accurate only if the gauge tube sensitivity is coordinated with the emission current and the controller sensitivity so as to give a one to one correlation between pressure and meter reading. There are several ways of establishing this relationship between the pressure and the pressure indication:

.1. A Good Method. Use the sensitivity listed by the tube manufacturer and Equation 1 to determine the emission current and electrometer sensitivity settings required for direct reading.

.2. A Better Method. All ionization gauge tubes vary somewhat from the nominal sensitivity stated by the manufacturer because of small uncontrollable geometrical variations in the tube. For better accuracy it is suggested that the ion gauge tube be calibrated in one or more gases by a reputable calibration service. A number of firms now offer this service at nominal cost, and several vacuum equipment manufacturers, including Granville-Phillips, supply complete Gauge Calibration Systems for those who wish to perform their own calibrations. Use the calibration data as illustrated in Example 2 below. Apply specific linearity corrections to each data point as required.

.3. The Best Method. Have the tube calibrated as indicated above, and the Controller calibrated for electrical accuracy. Use the ELECTROMETER SENSITIVITY to obtain the most convenient relationship, and apply a combination of tube and controller specific linearity connections to each data point as required.

.4. The Equation for Obtaining Direct Pressure Readings. The gauge tube specifications combine with the Controller specifications in accordance with the following equation when the controller is direct reading in pressure:

$$\frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times G = 1$$

Equation 1

The factors in Equation 1 are defined as follows:

A = Controller Nominal Sensitivity—
The Nominal Sensitivity of the Series 236 Controller is 10/torr with the use of 10 ma of emission current. If a gauge tube has a sensitivity between 10/torr and 100/torr, it can be made direct reading on this Controller by decreasing the emission current as illustrated in Example 1 below.

B = Tube Sensitivity for Calibrating Gas—
The sensitivity of the gauge tube is given by the manufacturer for a specific gas, usually nitrogen, in terms of so many amperes of ion current per torr of pressure per ampere of emission current.

$$\text{Sensitivity, } S = \frac{\text{Ion collector current (amps)}}{\text{Emission current (amps)} \times \text{Pressure (torr)}}$$

This figure is at best a single point calibration of the individual tube for the indicated gas, but is more commonly just the average or typical value obtained from testing a number of similar tubes. The accurate value for the sensitivity can only be determined by gauge tube calibration.

C = Minimum SENSITIVITY—
The Minimum SENSITIVITY is the SENSITIVITY Setting obtained when the ELECTROMETER SENSITIVITY control on the rear panel is set at its counterclockwise limit. This value is a function of the individual controller. Normal values fall between 1.8 and 2.1.

D = SENSITIVITY Setting—
The SENSITIVITY Setting is the meter reading obtained when the RANGE switch is in the SENSITIVITY position. The FUNCTION switch should be in the 3.5 or the 11 position as required to obtain the most accurate reading. Values between 2 and 10 are typical. The SENSITIVITY Setting may be adjusted via the ELECTROMETER SENSITIVITY control on the rear panel.

Thru its adjustable electrometer sensitivity the Series 236 Controller may be made direct reading for gauge tubes which have sensitivities between 2/torr and 10/torr. See Example 2.

E = Controller Nominal Emission Current—
The Nominal Emission Current for the Series 236 Controller is 10 ma.

F = Emission Current—
This is the emission current used. In some cases this will be the variable for which the equation is solved. In other cases this value will be supplied as that at which the tube was calibrated. For accurate measurements using a calibrated tube, changing the emission current is not desirable be-because it can disturb conditions within the gauge tube, and thus disturb the calibration. In no case should the emission current be set at a higher value than the maximum specified by the tube manufacturer.

G = Gauge tube Sensitivity for Calibrating Gas divided by Gauge tube Sensitivity for Measured Gas.

An ionization gauge tube has a different sensitivity for each gas or mixture of gases. If a tube has been calibrated for a given gas, e.g. nitrogen, and the controller is adjusted to be direct reading for this gas with this tube, then the Controller will not be direct reading for another gas, e.g. argon, unless the emission and/or electrometer sensitivity are changed.

The ratio of the gauge sensitivity for the calibrating gas to the gauge sensitivity for the gas to be measured may be determined experimentally, through calibration, or found in the literature. The ratios of sensitivities have been measured for most of the common gases, and are tabulated and discussed in Dushman and Lafferty, Scientific Foundations of Vacuum Techniques, Wiley, 1962. 2nd Ed. p. 321 ff. Example 3 illustrates the use of the sensitivity ratio in making the Controller direct reading for a gas other than the calibrating gas.

Example 1: The gauge tube manufacturer gives a value for the tube sensitivity for nitrogen of 12/torr. How should the Controller be adjusted to make it direct reading for nitrogen? Because the Controller Nominal Sensitivity is 10/torr, the emission must be decreased to make the controller direct reading. Thus Equation 1 should be solved for F and the following values substituted:

A = 10/torr

B = 12/torr

C = 1.95 (assumed value for this example)

D = 1.95 (use minimum as Controller is too sensitive even at the minimum).

E = 10.0 ma

G = 1.00 (Measured gas is the same gas as tne calibrating gas).

$$F = \frac{10/\text{torr}}{12/\text{torr}} \times \frac{1.95}{1.95} \times 10.0 \text{ ma} \times 1.00$$

$$= 8.33 \text{ ma}$$

Setting the emission current to 8.33 ma, and the electrometer sensitivity to its minimum value (1.95 for this particular Controller) will make the Controller direct reading for nitrogen.

Example 2: A gauge tube has been calibrated for argon using 4.00 ma emission current. The mean Tube Sensitivity value reported is 8.46/torr. How should the Controller be adjusted to make it direct reading for argon? It is not desirable to change the emission current from the calibration value, so only the electrometer sensitivity can be changed. Thus the equation must be solved for SENSITIVITY Setting, and the following values substituted:

A = 10/torr

B = 8.46/torr

C = 1.95 (assumed value for this example)

E = 10.0 ma

F = 4.00 ma

G = 1.00

$$D = \frac{10/\text{torr}}{8.46/\text{torr}} \times \frac{10.0 \text{ ma}}{4.00 \text{ ma}} \times 1.95 \times 1.00$$

$$= 5.75$$

Thus with the electrometer sensitivity set to give a SENSITIVITY reading of 5.75, and the emission current set to 4.00 ma, the Controller is direct reading for argon.

Example 3: The tube described in Example 1 is to be used to measure hydrogen gas. How should the Controller be adjusted to make it direct reading for hydrogen? From data given by Schultz[2]:

G = 2.43

Because the gauge is less sensitive to hydrogen than to nitrogen, the electrometer sensitivity must be reset to make the Controller direct reading for hydrogen. In order that the hydrogen readings be directly comparable with the previous nitrogen readings, the emission current should be kept the same, namely, 8.33 ma. In this case the equation should be solved for D and the following values substituted:

A = 10/torr

B = 12/torr (nitrogen)

C = 1.95(assumed value for this example)

E = 10 ma

F = 8.33 ma

G = 2.43

$$D = \frac{10/\text{torr}}{12/\text{torr}} \times \frac{10.0 \text{ ma}}{8.33 \text{ ma}} \times 1.95 \times 2.43$$

$$= 4.74$$

With the electrometer sensitivity set to give a SENSITIVITY reading of 4.74, and operating with 8.33 ma of emission current the Controller is direct reading for hydrogen.

Because the emission current can only be adjusted by a factor of ten without changing pressure range settings, and the electrometer sensitivity adjustment covers only a factor of five, not all conceivable tube parameter combinations can be made direct

2 G. J. Schulz, J. Appl. Phys. **28** 1149 (1957)

reading. The 50 fold range is sufficient, however, to permit convenient use of most commercial gauge tubes with most gasses. In cases outside this range a conversion factor or chart can be used to interpret the Controller pressure indications.

4.2.3 Reading the Pressure. The pressure information is displayed on the six inch mirror scale meter, on the scale determined by the setting of the FUNCTION switch. The meter reading must be multiplied by the RANGE switch setting to obtain the pressure.

For example, if the FUNCTION switch is set on the blue 3.5 position and the RANGE switch is set on 10^{-10}, a meter reading of 2.4 on the blue scale (0-3.5) would correspond to a pressure of 2.4×10^{-10} Torr assuming that the Controller has been correctly calibrated, that the emission is correct, and that the zero is in adjustment.

4.2.4 Measurement of Very Low Pressures. Several precautions are in order when measuring pressures below 10^{-9} Torr. The gauge tube should be shielded from sources of A.C. power. It is suggested that a grounded shield be placed around the tube, even a grounded loose wrap of aluminum foil will significantly decrease the noise level. Take care that the shield does not touch the collector. Extra care is required when degassing the gauge because the collector is at high voltage.

4.2.5 Recording Pressure. The Series 236 Controller provides RECORDER signals of five types:

.1. 0-10 v for each pressure decade, connect between GND and 10 v terminals. Signal is negative relative to ground.

.2. 0-100 mv for each pressure decade, connect between GND and 100 mv terminals. Signal is negative relative to ground.

.3. 0-10 mv for each pressure decade, connect between GND and 10 mv terminals. Signal is negative relative to ground.

.4. 9 mv per pressure decade stepping voltage, Connect between GND and 9 MV STEP terminals. Signal is positive relative to ground. This voltage is zero in the 10^{-11} torr decade, 9 mv in the 10^{-10} torr decade, etc.

.5. 0-11 mv meter monitor signal for Thermo Gauge, emission or calibration recording. See Section 4.2.6. The 10 v, 100 mv and 10 mv signals are conventional recorder signals which follow the meter indication when reading pressure on either the 3.5 or 11 scale. When the FUNCTION switch is turned to EMIS. position, the meter reads the emission current, but the recorder signals continue to indicate the electrometer output as though on the 11 scale. When the FUNCTION switch is turned to the 3.5 scale, connection no. 20 of the ACCESSORY SOCKET is grounded.

The best recording technique requires a two pen recorder, one for decade indication, the other for accurate recording within each decade. The decade is indicated by a 100 mv pen on 0-11 type chart paper. The amplifier for this pen is connected between the 9 mv jack and the 99 mv pin (no. 25) of the ACCESSORY plug. The appropriate pressure range is then given by the chart paper graduations, 6 for 10^{-6}, 8 for 10^{-8}, etc. A 110 mv pen is used on on the same 0-11 chart to record the pressure within the indicated decade. The amplifier for this pen is connected between ground and the -100 mv jack. The entire ion gauge pressure range may be recorded with a single pen 100 mv recorder by connecting the recorder between the -10 mv and 9mv STEP recorder jacks. In this mode of operation 9 decades of pressure can be recorded in a single pen sweep across the chart. Each decade occupies 1/11 of the total span of the recorder and in each decade the pen displacement varies linearly with pressure. Chart paper graduated 0-11 should be used.

An example will help to explain this mode of operation. Assume that the system pressure is to be increased linearly with time from 1×10^{-11} to $10 \times 10^{-11} = 1 \times 10^{-10}$ Torr. The 10mv recorder signal will increase linearly with time from 1 mv to 10 mv. This linearly increasing pressure will be recorded as a straight line between the 1 and 10 mv markings on the chart. If we continue to increase the pressure linearly with time from 1×10^{-10} to 10×10^{-10} Torr we must switch ranges. When we switch the RANGE switch to the X 10^{-10} range the 10 mv recorder output changes from its former 10 mv to 1 mv. To prevent the recorder pen from tracing over the previously recorded range, a 9 mv step signal is automatically added to the signal as the RANGE switch is switched to the X 10^{-10} range. Now the recorder can record the pressure in the 10^{-10} Torr range between the 10 and 19 mv positions on the chart. As the RANGE switch is switched to the X 10^{-9} Torr range another 9 mv step signal is added so that pressures in the 10^{-9} Torr decade can be recorded between the 19 and 28 mv chart positions, etc.

The signal output listed in 4.2.5.5. is for recording the meter output when the meter is reading the Thermo Gauge pressure, the calibration voltage, the emission current, or the ion gauge pressure. The meter monitor recorder connections are made via pins 21 and 8 of the ACCESSORY SOCKET. Pin 8 is negative relative to pin 21. The signal level is 0 to 11 millivolts. The connections are made across 100 ohms in series with the meter. Loading between these terminals will effect the meter behavior only when using the Thermo Gauge feature. It is thus desirable to calibrate the Thermo Gauge feature with any intended load in place. Do not ground.

The 10 and 100 millivolt recorder signals are derived from a resistor string attached to the electrometer amplifier output. Full scale current in these resistors is 1.0 millamperes.

The 10 volt output is attached directly to electrometer amplifier output. Up to 1 milliampere may be drawn from this connection, but there must be no capacitive loading of this point. The 9 millivolt Step terminal is driven with a 1 milliampere resistor string.

4.2.6 Thermo Gauge Operation. When the FUNCTION switch is turned to THERMO GAUGE and the filament is on, the ion gauge filament is connected into a constant current bridge circuit as a Pirani gauge. Pirani gauges suffer from a number of limitations which make them less than ideal pressure transducers. However, for pressure indication during rough pumping and similar applications in the awkward pressure range from 10 Torr to 10^{-3} Torr the Thermo Gauge is extremely useful.

When a new tube is installed, the Thermo Gauge circuit must be adjusted so that the meter reads the pressure properly. With the tube at atmosphere, the black Thermo Gauge ATM control on the front panel is set to make the meter read ATMOS. After the tube has been pumped down below 1×10^{-4} Torr the meter is zeroed on the right of the Thermo Gauge scale by adjusting the red THERMO GAUGE ZERO knob (not the METER ZERO control). The Thermo Gauge is now direct reading.

The THERMO GAUGE control on the rear panel adjusts the current through the filament for Thermo Gauge operation. This control is factory set at 1.0 ampere. For gauge tubes with delicate filaments, this much current may cause the filament to glow slightly under vacuum conditions. It is recommended in such a case that the current be adjusted downward. To measure the Thermo Gauge current, insert a 0-1.5 ampere DC meter in series with the filament. If the current is changed, the Thermo Gauge calibration procedure must be repeated.

4.3 DEGASSING THE GAUGE TUBE

As the pressure decreases in a system, outgassing of ion gauge tube electrodes and surfaces can contribute an increasingly large error to the pressure measurement.

The Series 236 Controller utilizes controlled electron bombardment degassing rather than the inexpensive, more commonly used resistance heating of the grid. Bombardment produces a much cleaner tube. It is easy to demonstrate this fact by outgassing a tube by resistance heating of the grid until gas is being evolved at a low rate. If the Series 236 Controller is now connected to the tube and the tube outgassed at 100W (watts). very large amounts of gas are evolved for considerable periods of time.

For best results a new or dirty tube should be wrapped with a blanket of glass wool about one inch thick and degassed at the highest power available which will not cause collapse of the glass. Caution should be used to leave the connecting plugs exposed so that they will not get too hot.

After degassing glass tubes at high power it is highly desirable to remove the glass wool wrap and switch to 30W (watts) degas power for 5 to 10 minutes. At 30 watts the glass decomposition products which were produced inside the tube are quickly removed and negligible amounts of new decomposition products are formed.[1] Thus a clean tube is produced quickly and reliably. It is important that the pressure in the system be 10^{-5} torr or less if degassing is to be effective.

4.4 THE AUTOMATIC RANGE SWITCH, OVER PRESSURE PROTECTION, AND PROCESS CONTROL RELAYS

All of these devices operate from the voltage which activates the meter, and thus operate at a fixed point on the meter face, as though they were meter relays. Their action is thus independent of the meter scale in use.

4.4.1 Automatic Range Switch Relays. On Controllers equipped with automatic range switching, set points are factory adjusted at 0.9 and 10.5 on the 0-11 scale. If readjustment is required, the set points may be changed via the AUTOMATIC RANGE SWITCHING - HIGH and LOW adjustments on the rear panel. Set points must be adjusted sufficiently far apart that oscillation does not occur. The low point should be set first. The procedure is as follows:

.1. Operate the filament with the POWER switch in the ON, (not AUTO) position.

.2. Place the FUNCTION switch in the 3.5 or 11 position as required.

.3. Set the meter zero very accurately, using the METER ZERO control.

.4. Set the emission current and RANGE switch such that a pressure reading at 10 times the desired set point is obtained. For example, obtain a reading of 9.0 on the 11 scale for setting the low set point.

.5. Turn the LOW adjustment to its counterclockwise limit (facing the rear panel).

.6. Turn the RANGE switch to the next higher pressure decade so that a reading of 0.9 is obtained on the 11 scale.

.7. Turn the POWER switch to AUTO.

.8. Turn the LOW adjustment clockwise very slowly just until the RANGE switch operates. The LOW adjustment is now completed.

.9. Turn POWER switch to ON position.

.10. Set the emisison current and RANGE switch such that a pressure reading of 10.5 is obtained.

.11. Turn HIGH adjustment to its clockwise limit.

.12. Turn POWER switch to AUTO.

.13. Turn the HIGH adjustment counterclockwise very slowly just until the RANGE switch operates. The HIGH adjustment is now complete.

.14. It is very important that the low limit be set by turning the adjustment clockwise facing the rear panel, and that the high limit be set by turning the adjustment counterclockwise.

.15. Vary the emission current to test the accuracy of the set points.

4.4.2 Overpressure Protection Relay. The correct setting of this relay is very important if the gauge tube filament is to be protected from burnout in the event of high pressures in the system.

When depending upon the OVER PRESSURE PROTECTION relay for safety shut down of the filament, it is important that the emission current be large enough that the ion current can easily exceed the relay set point. This will almost always be the case if the .1X and 1X EMISSION MULTIPLIER settings are used. When Automatic Range Switching is used, an additional safety feature is brought to bear, in that the RANGE switch will be driven into the SENSITIVITY position by large increases in pressure. The filament is off when the RANGE switch is in the SENSITIVITY position. In order for this to be an effective protective mechanism, it is important that the emission current be high enough that full scale on the highest available pressure range can be attained. One milliampere is an adequate current for most tubes. When the RANGE switch is in SENSITIVITY position, terminal 11 of the ACCESSORY SOCKET is connected to ground. When using automatic range switching, this feature may be used for safety circuits or warning systems.

NOTE: By turning the OVERPRESSURE PROTECT adjustment on the rear panel to its clockwise limit, the protection circuit is rendered inoperative. The settings which will give protection range from 8.5 to the equivalent of 16 on the 0-11 scale of the meter. The relay is factory adjusted to turn the filament off automatically when the meter is at an off scale reading of 14 (on the 11 scale).

.1. Check Procedure
To check the setting of this relay, proceed as follows:

Operate the Controller with the filament ON, and the POWER switch in the ON (not AUTO) position. Place the FUNCTION switch in the 11 position.

Adjust the emission current such that it can cause pressure indications from approximately 0.8 to 1.6 on the scale as the red EMISSION CURRENT ADJUST knob is rotated.

Set the emission current to the low end of this range.

Switch the RANGE switch such that the pressure indications becomes approximately 8.

Turn the EMISSION CURRENT ADJUST clockwise very slowly (note that there is a time delay of as much as 2 seconds) until the filament shuts off.

Return the RANGE switch to its previous setting.

Turn the filament back on. The reading of the meter is now one tenth of the setting of the OVER PRESSURE PROTECTION relay.

.2. Set Procedure
To set the OVER PRESSURE PROTECTION relay:

Repeat steps 1 and 2 of 4.4.2.1 check procedure.

Turn the OVER PRESSURE PROTECT adjustment to its clockwise limit.

Set the emission current to give a pressure reading of 1.4 on the 11 scale.

Turn the RANGE switch to the next lower pressure decade. This will give a greater than full scale meter reading.

Turn the OVER PRESSURE PROTECT adjustment slowly counterclockwise until the filament shuts off.

Check the setting using the check procedure 4.4.2.1.

4.4.3 Process Control Relay. The process control relay is available for the automatic operation of external equipment. It functions at a given point on the meter scale, as though it were a meter relay. The pressure at which it operates thus depends upon the choice of pressure scales. The relay operates in each pressure decade, opening as the set point is exceeded. Selector switches may be mounted on the switching motor shaft extension to limit the effective switching action to a given desired decade. The range of adjustment of the process control relay is from 1 (on the 11 scale) to well beyond full scale. Factory adjustment is for beyond full scale.

.1. Check Procedure.
To check the reading of the meter at which the relay actuates, proceed as follows:

Operate the Controller with the filament ON, and the POWER switch in the ON (not AUTO) position.

Place the FUNCTION switch in the 11 position.

Adjust the emission current such that the 1-3 portion of the meter scale is traversed by the pressure indication as the emission current is changed using the red EMISSION CURRENT ADJUST control.

Connect an ohmmeter between terminals 4 and 5 of the ACCESSORY SOCKET. This should be a short circuit until the PROCESS CONTROL relay is activated.

Use the EMISSION CURRENT ADJUST control to vary the pressure indication. Watch the ohmmeter for a change in the relay status.

If the set point is not found on the lower portion of the scale, change the FUNCTION switch to the 3.5 position and repeat the last step.

The EMISSION CURRENT ADJUST control range should now cover the upper portion of the meter scale. Scan the upper portion of the meter scale. If the set point is not here either, it is set beyond the meter scale.

.2. Set Procedure. To set the PROCESS CONTROL relay:

Repeat steps 1 and 2 of 4.4.3.1 above.

Adjust the emission current such that the pressure indication is at the point on the meter where the relay set point is desired.

Set the PROCESS CONTROL potentiometer on the rear panel to its clockwise maximum (facing rear panel).

Slowly adjust the PROCESS CONTROL potentiometer counterclockwise until the relay operates.

Check the setting by varying the emission current while watching the ohmmeter. The PROCESS CONTROL relay operates in each decade unless held closed by connecting terminal 9 of the ACCESSORY SOCKET to terminal 22 (ground). External switches may be mounted on the rear extension of the switching motor shaft if it is desired to limit switching action to one decade, or to obtain other special effects.

4.5 GRID VOLTAGE

The grid circuit is shown in Figure 4. Grid voltage may be measured between the grid of the gauge tube and ground. A vacuum tube voltmeter should be used. NOTE: DO NOT CONNECT METER TO THE COLLECTOR LEAD. It is important that the gauge tube be operating at the desired emission. It is desirable that the EMISSION MULTIPLIER be in the 1X position, and important that the filament be in operation. Be very careful that the grid connection to the tube is not impaired in setting up for this measurement. If the grid connection is lost, the filaments will probably be destroyed.

Adjust the grid voltage to the desired value using the GRID VOLTAGE control on the rear panel. Factory adjustment is for +175 volts relative to the collector (ground).

4.6 ACCESSORY SOCKET

Connections for the numerous auxiliary functions available are made via the ACCESSORY SOCKET on the Controller rear panel. See Figure 5 for details. Note the use of pins 13, 22, 16 and 3 for remote operation of the filament.

4.7 LINE VOLTAGE CONVERSION

Conversion of the 105-125 VAC Controller for operation at 210-250 VAC:

4.7.1. Disconnect the Controller from the mains.

4.7.2. Face rear of Controller.

4.7.3. Remove top cover.

4.7.4. Identify the transformer jumper leads indicated by the A and B hexagons in figure 6A.

4.7.5. Remove the blue wire jumper (A) between terminals 1 and 4.

4.7.6, Remove the brown wire jumper (B) from terminal 5, and

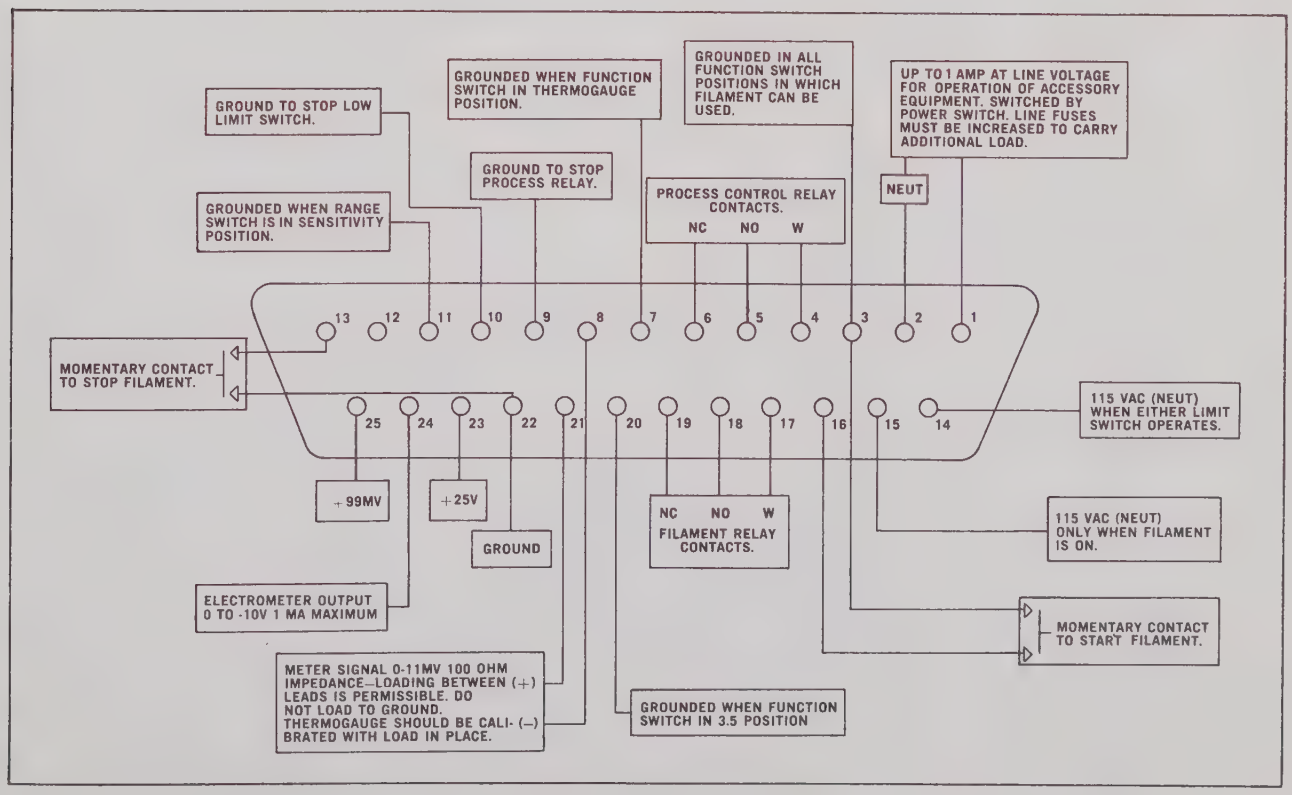
GROUND TO STOP LOW LIMIT SWITCH.
GROUNDED WHEN FUNCTION SWITCH IN THERMOGAUGE POSITION.
GROUNDED IN ALL FUNCTION SWITCH POSITIONS IN WHICH FILAMENT CAN BE USED.
UP TO 1 AMP AT LINE VOLTAGE FOR OPERATION OF ACCESSORY EQUIPMENT. SWITCHED BY POWER SWITCH. LINE FUSES MUST BE INCREASED TO CARRY ADDITIONAL LOAD.
GROUND TO STOP PROCESS RELAY.
NEUT
GROUNDED WHEN RANGE SWITCH IS IN SENSITIVITY POSITION.
PROCESS CONTROL RELAY CONTACTS.
NC NO W
13 12 11 10 9 8 7 6 5 4 3 2 1
MOMENTARY CONTACT TO STOP FILAMENT.
25 24 23 22 21 20 19 18 17 16 15 14
115 VAC (NEUT) WHEN EITHER LIMIT SWITCH OPERATES.
+99MV
+25V
GROUND
NC NO W
FILAMENT RELAY CONTACTS.
115 VAC (NEUT) ONLY WHEN FILAMENT IS ON.
ELECTROMETER OUTPUT 0 TO -10V 1 MA MAXIMUM
MOMENTARY CONTACT TO START FILAMENT.
METER SIGNAL 0-11MV 100 OHM IMPEDANCE—LOADING BETWEEN (+) LEADS IS PERMISSIBLE. DO NOT LOAD TO GROUND. THERMOGAUGE SHOULD BE CALI- (—) BRATED WITH LOAD IN PLACE.
GROUNDED WHEN FUNCTION SWITCH IN 3.5 POSITION

Figure 5. Accessory socket connections.

connect it to terminal 4.

4.7.7. The resulting connection should look like that shown in Figure 6B.

4.7.8. Change the power fuses from 2 ampere (Slo-Blo type) to 1 ampere (Slo-Blo type).

4.7.9. Install the decal provided.

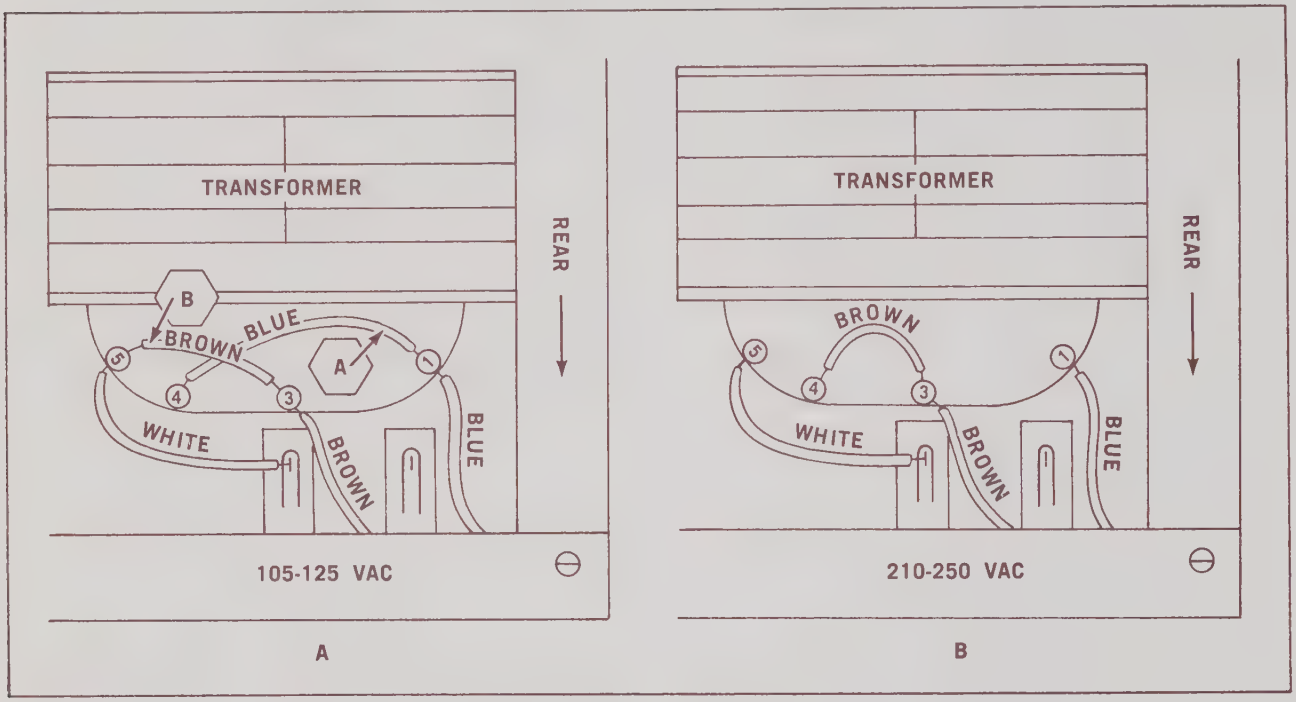

Figure 6 Transformer connections.

5.0 TROUBLESHOOTING

Your Series 236 Ionization Gauge Controller will provide long, trouble-free service if properly used and cared for. Should you experience difficulties in operating it, the following information will be useful. If prescribed remedies do not correct troubles, or if additional assistance is required, contact the Technical Service Department, Granville-Phillips Company, 5675 East Arapahoe Ave., Boulder, Colorado, or call Area Code 303, 443-7660.

SYMPTOM—POSSIBLE CAUSE	REMEDY
5.1 A.C. POWER AND FUSES	
5.1.1 Pilot Light Will Not Come On	
.1. Power cord not plugged in.	Plug in power cord.
.2. No power in mains.	Restore power service.
.3. Controller power fuse blown (2 amp. 110V) (1 amp. 220V)	Replace fuse—See 5.1.2.
5.1.2 Controller Power Fuse Blows	
1. Incorrect power source.	Check power source vs Controller requirements.
2. Incorrect fuse rating.	Use correct fuse—See 5.1.1.3.
3. Combination of Controller plus Accessory plug AC load too heavy for fuse.	Use adequate fuse—**not to exceed 3 amp.** Accessory plug rated for 1 amp AC.
4. Short circuit in Accessory Plug A.C. connections.	Remove short.
5. Gauge tube filament shorted (Fuse blows when filament is turned on)	Replace filament or gauge tube.
6. Gauge cable or plug shorted.	Repair or replace cable.
5.2 FILAMENT PROBLEMS	
5.2.1 Filament Will Not Light (Filament Pilot Comes On).	
.1. Gauge tube not connected.	Connect gauge tube—See Fig. 3.
.2. Gauge tube not properly connected.	Connect tube correctly—See Fig. 3.
.3. Gauge cable—plugs faulty contact.	Clean contacts—replace plugs if badly pitted.
.4. ¼ amp fuse blown.	Replace fuse—See 5.6.2.
.5. Filament burned out.	Replace filament or gauge tube.

SYMPTOM—POSSIBLE CAUSE	REMEDY
5.2.2. Filament Will Not Light (Filament Pilot Light Does Not Come On)	
.1. FUNCTION switch in CALIBRATE or STANDBY position.	Turn FUNCTION switch to 3.5, 11 or EMIS position.
.2. RANGE switch in SENSITIVITY position.	Turn to pressure position.
.3. Remote filament control connections on accessory plug shorted.	Remove shorts.
.4. Control relay (K 1356) not firmly in its socket.	Plug relay in properly.
.5. Control relay faulty (K-1356).	Replace relay.
.6. Filament OFF switch contacts dirty.	Wear contacts clean by pushing OFF button repeatedly.
5.2.3. Filament Shuts Off Automatically	
.1. Pressure too high.	Decrease pressure.
.2. Momentary A.C. power failure.	Restart filament.
.3. Momentary pressure burst.	Restart filament.
.4. RANGE switch set to lower decade than system pressure.	Switch to more appropriate pressure range.
.5. Incorrect connection to gauge tube.	Correct tube connection—See Fig. 3.
.6. Gauge tube contaminated inside.	Clean tube.
.7. Gauge tube contaminated outside.	Clean tube.
.8. Faulty control relay (K 1356).	Replace relay.
5.2.4 Filament Temperature Is Too High And No Emission Current Is Indicated (Most Filaments Operate At Bright Orange Temperature, Not White Hot Or Incandescent)	
.1. Grid circuit is open.	Check grid lead continuity and connection.
.2. Pressure is very high (greater than 50u).	Reduce pressure.
5.2.5 Filament Temperature Is Too High And Inadequate Emission Current Is Measured.	
.1. Poor connection to grid.	Check grid connection.
.2. Filament unable to supply desired emission.	
.1. Filament emissive coating is degraded.	Replace filament or tube.
.2. Contaminated tungsten filament.	Operate at reduced emission current such that filament is not "out of control," lower system pressure, degas gently.
.3. Pressure is very high.	Reduce pressure.
5.2.6 Filament Temperature Is Too High But Proper Emission Current Is Measured.	
.1. Contaminated tungsten filament.	See 5.2.5.2
.2. Filament emissive coating degraded.	Replace filament or tube if desired. As long as proper emission current is maintained, pressure reading is unaffected.
5.2.7 Filament Flickers	
.1. Mechanical vibration against support.	May not be serious if pressure reading is not affected. Change tube or shock mount appropriate parts of system.
.2. Intermittent connection.	Check connections.
.3. Unstable emission current.	See 5.3.3
.4. Degraded filament emissive coating.	See 5.2.6.2
5.2.8 Filament Does Not Turn Off With Overpressure	
.1. Overpressure protection misadjusted.	Readjust—See 4.4.2
.2. Emission current set too low.	Use 1ma or greater emission current for situations where fail-safe action is required.
5.2.9 Filament Will Not Turn Off	
.1 Control relay stuck (K-1356).	Replace relay or clean contacts.
.2. Ambient temperature at rear of Controller outside allowable limits.	Furnish adequate ventilation.
.3. Accessory plug remote filament connections shorted.	Repair connections.
5.3 EMISSION CURRENT PROBLEMS	
5.3.1 No Emission Current Is Indicated	
.1. FUNCTION Switch is not in EMIS position.	Turn FUNCTION Switch to EMIS position.
.2. Filament is not on.	Turn on filament.
.3. Tube is not properly connected.	Grid not connected—See Fig. 3.
.4. Filament is burned out.	Replace filament or tube.
.5. ¼ ampere fuse blown.	Replace fuse.
5.3.2 Emission Current Cannot Be Adjusted To Desired Value	
.1. Poor connection to filament or grid.	Clean connections.

SYMPTOM—POSSIBLE CAUSE	REMEDY
.2. Incorrect meter scale used for emission current measurement.	See Table 1
.3. Emission limit potentiometer incorrectly adjusted.	See 4.1.5
.4. Filament unable to supply desired emission.	See 5.2.5
.5. Filament requires more power than is available from controller.	Use lower emission current, change filament or tube.
.6. Filament turns off while emission current is being adjusted.	Pressure has exceeded full scale—turn Range Switch to higher pressure range.
5.3.3 Unstable Emission Current	
.1. Poor electrical connection to the filament and/or grid.	Clean connections.
.2. Filament emissive coating degraded.	Replace filament or tube.
.3. Electrical leakage between tube elements.	Clean or replace tube.
.4. Electrical interference from high frequency or high voltage discharge in the vacuum system.	Make provision to prevent discharge from reaching ion gauge tube.
.5. Glow discharge in gauge tube.	Decrease pressure, clean tube.
.6. A.C. line voltage outside of limits specified.	Control A.C. line.
.7. Faulty control relay (K-1356).	Replace relay.
5.4 PRESSURE MEASUREMENT PROBLEMS	
5.4.1 No Pressure Indication	
.1. FUNCTION switch not in 11 or 3.5 PRESSURE positions.	Turn to 3.5 or 11 position.
.2. Filament not on.	Turn on filament.
.3. Collector and/or gauge cable not properly connected to same tube.	Check connections to tube.
.4. RANGE switch set for pressure much greater than system pressure.	Turn RANGE switch to correct range.
.5. Collector cable shorted.	Repair cable.
.6. Electrometer tube failure.	Replace electrometer tube.
.7. Meter Zero Check switch stuck.	Remove bottom cover, and adjust switch position. Bracket may have been sprung by forcing circuit board into position.
5.4.2 Unstable Pressure Indication	
.1. Unstable emission current.	See 5.3.3
.2. Unstable system pressure.	Stabilize system pressure.
.3. Poor connection to collector.	Clean connections.
.4. Electrical noise from power lines, fluorescent lights, personnel moving near the gauge tube, moving collector cable, etc.	Shield tube with grounded wrap of aluminum foil.
.5. A.C. line voltage outside of limits specified.	Obtain proper voltage.
.6. Electrical leakage in gauge tube or collector cable.	Clean, repair or replace.
.7. Electrometer tube intermittent.	Replace electrometer tube.
.8. Electrometer tube, range resistors, range switch or electrometer connections dirty.	Clean with appropriate greaseless solvent.
.9. 10 volt recorder Jack carrying too heavy a load.	Reduce load to 1 ma at full scale.
.10. 10 volt recorder Jack capacitively loaded.	Remove capacitive load.
5.4.3 Unreasonable Pressures Indicated	
.1. Incorrect emission current.	See 4.1.2
.2. Poor connection to collector.	Clean connections.
.3. Failing electrometer tube.	Replace electrometer tube.
.4. Misset electrometer zero.	See 3.1.2 or 4.2.1.1
.5. Pressure greater than about 50u.	Reduce system pressure.
.6. Pressure read on incorrect meter scale.	See positions of both RANGE and FUNCTION switches.
.7. Filament not on, and electrometer zero misset.	Reset zero and turn on filament.
.8. Gas composition different than anticipated.	Set ELECTROMETER SENSITIVITY and/or have tube calibrated for gas to be measured.
.9. ELECTROMETER SENSITIVITY misset.	See 3.1.3
.10. Electrometer tube, range resistors or switch dirty.	See 5.4.2.8
.11. Electrical leakage in gauge tube or collector cable.	Repair or replace.
.12. Electrical or magnetic interference with gauge tube.	Use shielding around gauge tube.
.13. Leak in vacuum system.	Repair system.
.14. Dirty gauge tube.	Degas tube—See 3.3

SYMPTOM—POSSIBLE CAUSE	REMEDY
.15. Gauge tube uncalibrated.	Have gauge tube calibrated.
5.4.4 Pressure Indication Changes as EMISSION MULTIPLIER Is Used	
.1. Change in outgassing rate.	Degas tube thoroughly.
.2. Change in tube pumping.	Normal.
.3. Different tube characteristic with different emission current.	Expected especially at high pressures.
.4. Change in noise level.	Normal consequence of changing range resistors. Use greater emission current range for less noise.
5.4.5 Violent Meter Excursions When FUNCTION Switch Is Turned To 3.5 or 11 Positions, Relieved By Pressing ZERO CHECK	
.1. Shorted collector cable.	Repair cable.
.2. Collector connector inadvertently grounded.	Connect tube correctly.
.3. Severe electrical leakage to collector.	Clean tube or replace.
5.4.6 Violent Meter Excursions When FUNCTION Switch Is Turned to 3.5 or 11 Positions, Not Relieved by Pressing ZERO CHECK	
.1. Non-functional electrometer tube.	Replace electrometer tube.
5.5 AUTOMATIC RANGE SWITCHING PROBLEMS	
5.5.1 Automatic Range Switch Inoperative	
.1. POWER switch not turned to AUTO position.	Turn POWER switch to AUTO.
.2. POWER switch will not turn to AUTO position.	Manual Unit not intended for AUTO operation.
.3. Range relays not firmly seated in their sockets.	Plug in relays. Use hold down wires.
.4. Switch points misset.	See 4.4.1
.5. A.C. line voltage outside of specified limits.	Obtain specified voltage.
.6. Faulty range relays (K1167-2, 3)	Replace relays.
.7. Accessory plug contacts shorted.	Repair accessory plug.
5.5.2 Automatic Range Switch Oscillates	
.1. System pressure is fluctuating near the set points.	Stabilize pressure.
.2. Unstable pressure reading is obtained.	See 5.4.2
.3. Set points overlap due to missetting	Reset setpoints—See 4.4.1
5.5.3 Automatic Range Switch Goes Into SENSITIVITY Position	
.1. Pressure is too high.	Reduce system pressure.
5.5.4 Filament Turns Off Instead of Automatic Range Switch Changing To Higher Pressure Range	
.1. Upper switch point set too high.	Reset upper switch point (4.4.1)
.2. Overpressure Protection set too low.	Check Overpressure Setpoint (4.4.2.2)
.3. Pressure increase was extremely large and fast.	Normal behavior in this case.
5.6 DEGASSING PROBLEMS	
5.6.1 Filament Goes Off	
.1. Momentary A.C. Power failure.	Restart filament.
.2. Accessory plug remote filament operation contacts shorted.	Repair plug.
.3. ¼ ampere fuse blown.	Replace fuse—See Degas Instructions 3.3 and 5.6.2.
5.6.2 ¼ Ampere Fuse Blows	
.1. Tube elements very dirty (violent glow discharge).	Degas with less power.
.2. Start with too much degas power.	Decrease degas power.
.3. Tube elements shorted (may occur at high temperature).	Limit power, re-orient tube, or replace tube.
.4. Collector lead shorted or inadvertently grounded.	Remove short.
.5. System pressure too high.	Reduce system pressure.
.6. Inadequate conductance between gauge tube and pump.	Modify system design or degas very gently.
.7. Inadequate system pumping speed for tube condition and degas power level.	Degas more gently.
5.7 THERMO GAUGE PROBLEMS	
5.7.1 Thermo Gauge Reading Is Unstable	
.1. Inadequate contact at filament connections or gauge plug.	Clean or renew contacts.

SYMPTOM—POSSIBLE CAUSE	REMEDY
.2. Tube is changing temperature.	Wait for better stabilized temperature.
.3. Load changing on pins 8 and 21 of Accessory plug.	Stabilize load on plug and recalibrate.
.4. A.C. line voltage out of prescribed limits.	Obtain rated line voltage.
.5. Mechanical vibration of filament against its supports.	Re-orient tube or shock mount appropriate parts.
5.7.2 Thermo Gauge Reading Is Off Scale	
.1. Insufficient time allowed for equilibration at time of ATMOSPHERIC or ZERO calibration.	Recalibrate, allowing at least five minutes at each point.
.2. Pressure not sufficiently low at ZERO calibration.	Recalibrate ZERO with lower pressure.
.3. Gas composition different from that at calibration.	Recalibrate with appropriate gas.
.4. Filament condition different from that at calibration.	Recalibrate.
.5. Different gauge cable than used for calibration.	Recalibrate.

6.0 SPECIFICATIONS

6.1 PHYSICAL

Width (front panel)	19"
Height (front panel)	7"
Depth	9¼" behind panel
Recommended mounting depth	11" min.
Weight	20 pounds
Shipping weight	30 pounds
Panel finish	Anodized aluminum
Mounting Position	Horizontal only
Maximum ambient temperature	50° C (122° F)

6.2 ELECTRICAL

Power requirements	105-125 VAC 50/60 cps 2 amperes, single phase and 210-250 VAC 50/60 cps 1 ampere, single phase. Standard 105-125 volt units may be quickly changed to 210-250 volt operation by the customer. See section 4.7 for conversion instructions.

6.3 OPERATIONAL

Filament Circuit	
Filament potential relative to collector	+ 25 volts
Maximum continuous filament power	80 watts
Maximum continuous filament current	6 amperes
Grid Circuit-Normal Operations	
Grid potential relative to filament	+160 volts adjustable over ± 10%.
Emission current	10 ua to 10 ma
Grid Circuit-Degassing Operation	
Grid potential relative to filament	+600 volts
Emission current	13 to 170 ma
Emission Control Amplifier	
Open loop gain	greater than 10,000
Signal voltage	2.5 to 7.5 volts
Current sensing resistor tolerance	½%
Drift vs temperature	less than 1% from 20° to 50° C
Electrometer Circuit	
Collector potential relative to ground	0.00 volts
Input current range	10^{-5} to 3.0×10^{-12} amperes full scale
Electrometer amplifier open loop gain at DC	10,000
Electrometer zero drift vs time (after 30 minute warmup).	0.3% of full scale /hr or 5×10^{-13} amps/hr. whichever is larger.
Electrometer zero drift vs temperature	.03% of full scale /C° or 5×10^{-13} amps/C° whichever is larger.
Electronic capability for std. gauge tube with sensitivity of 10 per Torr.	10^{-1} to 3×10^{-11} torr full scale.
Meter	
Calibrated accuracy and tracking	± 1% of full scale
Linear Scales	0-3.5 and 0-11 mirrored.
Thermo-Gauge* Scale	atmosphere to 0
Recorder Signals	
0-10v (0 to 10 on scale)	(1ma max load)
0-10 mv (0 to 10 on scale) across	10 ohms
0-100 mv (0 to 10 on scale) across	100 ohms
9 mv per pressure decade (0 on 10^{-11} range)	10 ohms per decade
Gauge Tube Requirement	Standard Bayard-Alpert type available from most manufacturers.
Thermo-Gauge* Function—Tube Filament Operating as a Pirani Gauge	
Bridge Current	Adjustable .8-1.2 amps typical
Pressure Range	10 to 10^{-3} Torr
Readout	
Meter	Separate meter scale
Recorder Output	10 mv across 100 ohms.

WARRANTY

The Company warrants that each item of merchandise sold by it is free from defects in workmanship or material and it will replace or repair any item found to be defective in workmanship or material upon return of the same to the Company office. On electronic equipment, this warranty is limited to a period of one full year extending from the date of original shipment. The liabilities arising out of the supplying of said products or their use whether on said warranties or otherwise, shall in no case exceed the cost of correcting defects in the product. No other warranty, expressed or implied, is assumed or will be assumed.

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MODEL 02 IONIZATION GAUGE CONTROLLER – PARTS LIST

On the schematic, alphabetical prefixes indicate type of part, C for capacitor, R for resistor, etc. A suffix number after the dash indicates the individual part identification where several identical parts are used. Suffix letters indicate portions of a single part, central 3 to 4 digit number is sufficient identification for ordering parts. A star (*) indicates a part that should be obtained from Granville-Phillips Company in order to be sure of interchangeability. In many cases, other parts may be obtained most economically from your local electronics supplier.

Capacitors (C)

1381	.1mf 200v Sprague 192P10492 only
1382	22mf 15v Sprague 226X9015B2
1383	4.7mf 35v Sprague 150D475X9035B2 only
1385	2.2mf 35v Sprague 150D225X9035B2 only
1388	.047mf 200v Sprague 192P47392 only
1389	.022mf 200v Sprague 192P22392 only
1390	20pf Centralab polystyrene only
1459	4700pf Centralab polystyrene only
1460	2200pf Centralab polystyrene only
1461	390pf Centralab polystyrene only
1462	100pf Centralab polystyrene only
1570	250mf 75v Sprague 39D257G075JE0 only
1571	50mf 50v Sprague 39D506G050EE0 only
1572	90mf 100v Sprague 39D906F100HE0 only
1574	20mf 450v Sprague 39D206F450GL4
1575	2600mf 15v Sprague 39D208G015JJ0 only
1576	450mf 25v Sprague 39D475G025FJ0 only

Diodes (D)

726	200 PIV 1 amp
959	Zener 6.8v 400mw 5% 1N754A
960	Zener 9v 1N935
979	50 PIV 10W 15 amp 368A Westinghouse
1391	Zener 5.6v 400mw 10% 1N752
1392	50 PIV 2 amp Si Slader SLA23
1393	Bridge, Diodes Inc. 5164
1394	Zener 120v 10W 5% 1N3008B

Fuses (F)

1077	Holder, Little Fuse 3AG342022
1082	3AG ¼ amp FB
1176	3AG 2 amp SB
1213	3AG 1 amp SB (205-250v units)

Knobs

*200	Range switch knob assy.
343	Raytheon 70-3-2G ¼ Skt.
*445	Range switch
065	Raytheon 70-3-1G ⅛ Skt.
1066	Raytheon R50-IWD-IG ⅛ red
1067	Raytheon 70-3CB-2G ¼ thru Skt.
1365	Raytheon 70-2-2G ¼
1364	Raytheon 70-2CB-2G ¼ thru

Miscellaneous Hardware

*231	Heat sink Assy.
*447	Coupling, switch drive
527	Pin spring .094 dia. x .50 long
*545	Shield, zero switch
*547	Cover ,ion gauge
*549	Electrometer, shield
550	Shield, range switch
810	Pilot light, Ucinite 181407
*942	Decal, high voltage
*1036	Meter & Bezel 1602 Special API
*1069	Decal, range switch
*1355	Transformer, power TEC AV-1514 0000 13
*1374	Motor, Automatic Range Switching
*1454	Skirt–range switch

Plugs (P)

1076	Power Amph. 160-3
1366	UG1050/U FXR (on ckt. board)
1445	25 pin Cannon DB25P
1446	Plug cover Cannon DB51213-1

Resistors (R)

292	100K ohm ½W 5%
299	150K ohm ½W 5%
379	100 ohm ½W 5%
462	1K ohm ½W 5%
464	10K ohm ½W 5%
465	4.7K ohm ½W 5%
467	47K ohm ½W 5%
617	15K ohm ½W 5%
831	6.8K ohm ½W 5%
964	Pot. multi-turn 5K ohm ww ½W Bourns 3067P
966	Pot. 10K ohm CTS
967	Pot. 1K ohm CTS
995	75 ohm ww 5W 3%, Dale RS-5
997	220 ohm ½W 5%
1002	300 ohm ½W 5%
1006	680 ohm ½W 5%
1012	3.3K ohm ½W 5%
1017	10K ohm ½W 1% 100ppm
1020	12K ohm ½W 5%
1023	22K ohm ½W 5%
1024	25K ohm ½W 1% 100ppm
1025	27K ohm ½W 5%
1028	51K ohm ½W 5%
1030	100K ohm ½W 1% 100ppm Dale MFF-½
1031	220K ohm ½W 5%
1037	2K ohm 1W 3% ww
1053	100 ohm ½W 1% 100ppm Dale MFF-½
1056	900 ohm ½W .5%, 100ppm, Dale MFF-½
1060	100m ohm 1%, 600ppm, Dale DC-2 only
1061	1000m ohm 1%, 700ppm, Victoreen RX-1 only
1062	10,000m ohm, 1%, 800ppm, Victoreen RX-1 only
1144	10m ¼W 5%
1331	20K ohm ½W 1%, 100ppm
1395	18K ohm ½W .1%, 100ppm, Dale MFF-½
1396	10m ohm, 2W, .5%, 100ppm, Dale MFF-2 T1 only
1397	21.6K ohm ½W .5%, 100ppm, Dale MFF-½
1398	14.6K ohm ½W, .5%, 100ppm, Dale MFF-½
1399	9.8K ohm ½W, .1%, 100ppm, Dale MFF-½
1400	1.11K ohm ½W, .5%, 100ppm, Dale MFF-½
1401	4.63K ohm ½W, .5%, 100ppm
1402	101 ohm ½W, .5%, 100ppm, Dale MFF-½
1403	75K ohm ½W, .5%, 100ppm, Dale MFF-½
1404	237K ohm ½W, .5%, 100ppm, Dale MFF-½
1405	7.5K ohm, ½W, .5%, 100ppm, Dale MFF-½
1406	23.7K ohm, ½W, .5%, 100ppm, Dale MFF-½
1407	2.37K ohm ½W, .5%, 100ppm, Dale MFF-½
1408	42 ohm ww 3% 5W, Dale RS-5
1409	30 ohm ww, 3%, 5W, Dale RS-5

Resistors (R)

1410	1 ohm ww, 3%, 5W, Dale RS-5
1411	680K ohm 5%, 1W
1412	300 ohm 2W, 3%, ww, Dale RS-2A
1413	850 ohm, 2W, 3%, ww Dale RS-2A
1414	270 ohm 5W, 3%, ww Dale RS-5
1415	250 ohm 5W, 3% ww Dale RS-5
1416	10K ohm 10W, 3% ww Dale RH-10
1419	306 ohm ½W, .5%, 100ppm
1420	326 ohm ½W, .5%, 100ppm, Dale MFF-½
1421	23K ohm ½W, .5%, 100ppm, Dale MFF-½
1422	10 ohm ½W, 1%, 100ppm, IRC CEC
1423	90 ohm ½W, .5%, 100ppm, Dale MFF-½
1424	9.9K ohm ½W, .5%, 100ppm, Dale MFF-½
1425	1K ohm ½W, .5%, 100ppm
1426	9K ohm ½W, .5%, 100ppm, Dale MFF-½
1427	2K ohm ½W, .5%, 100ppm, Dale MFF-½
1428	64.9K ohm ½W, 1%, 100ppm, Dale MFF-½
1429	100 ohm ½W, 1%, 100ppm
1430	750 ohm ½W, .5%, 100ppm
1431	3 ohm 25W, 3%, ww Dale RH-25
1432	15K ohm ½W, 1%, 100ppm
1433	8.2K ohm ½W, 1%, 100ppm
1434	39K ohm ½W, 5%
1435	0.1 ohm 10W, 3%, ww Dale RS-10
1436	Pot. 100 ohms, 1K ohms Dual, CTS 39612
1437	Pot. 5K ohm
1438	Pot. 2K ohm, 5%, 10T, 2W, Bourns 3507S-1-202
1439	Pot. 3 ohm, ww, 5W, 10%
1440	Pot. 25K ohm, ww, 5W, 10%
1447	1m ohm ½W, 1%, 100ppm, Dale MFF-½
1522	2.5K ohm 5W, 5%, Ohmite 995-5B only
1530	27.8K ohm ½W, 1%, 100ppm
1541	150 ohm ½W, 5%
1542	Pot. multiturn 10K ohm ww, ½W, Bourns 3067P

Relays (K)

1167	Relay Allied TS154CC only
1356	Relay Allied T1634C only

Relay Hardware

1165	Socket & retainer for 1167 relay–Allied 30055-3
1166	Socket & retainer for 1356 relay–Allied 30055-4

Sockets and Jacks (J)

321	Jack, Donmar #721 red
578	Jack, Donmar #721 grey
624	Socket, BNC UG1094/U
728	Jack, Donmar #721 yellow
972	Jack, Donmar #721 black
973	Jack, Donmar #721 blue
1318	Socket, 6 pin Amph. 78S6
1371	22 conn. socket Viking 22S/1-2
1372	Socket, UG-1051/U FXR
1373	25 conn. socket Cannon DB25S

Switches (SW)

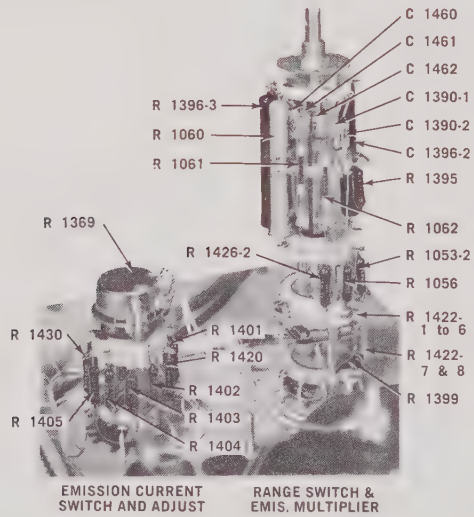
1038	Red Swcraft TY903 SPDT momentary push button
1039	Blk Swcraft TY913 SPDT momentary push button
1042	Micro Min. Honeywell 1PB5
*1367	Power CTS
*1368	Function CTS
*1369	Emission CTS, pot. attached Type AW 10K
*1370	Range CTS

Transistors (Q)

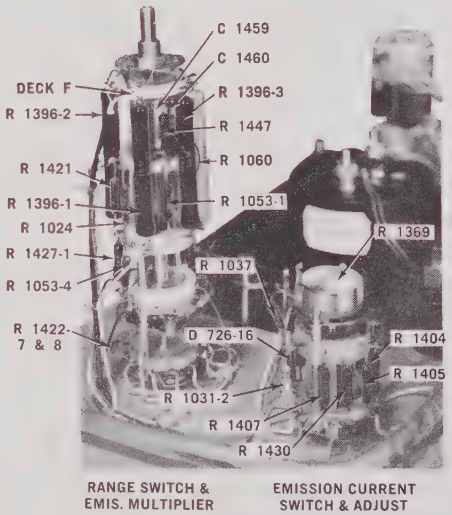
*961	Fairchild S7929 only or use Motorola 2N3467
962	Fairchild 2N956
1376	RCA 2N2270
1377	Motorola 2N2156

Tubes (V)

965	Raytheon CK5886 Electrometer

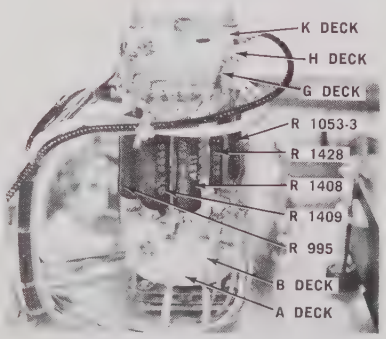


View up from meter terminals.



View from left side of chassis.

Function Switch from the bottom.



Function Switch from the top.

Figure 5. Location of components on Range and Emission switches.

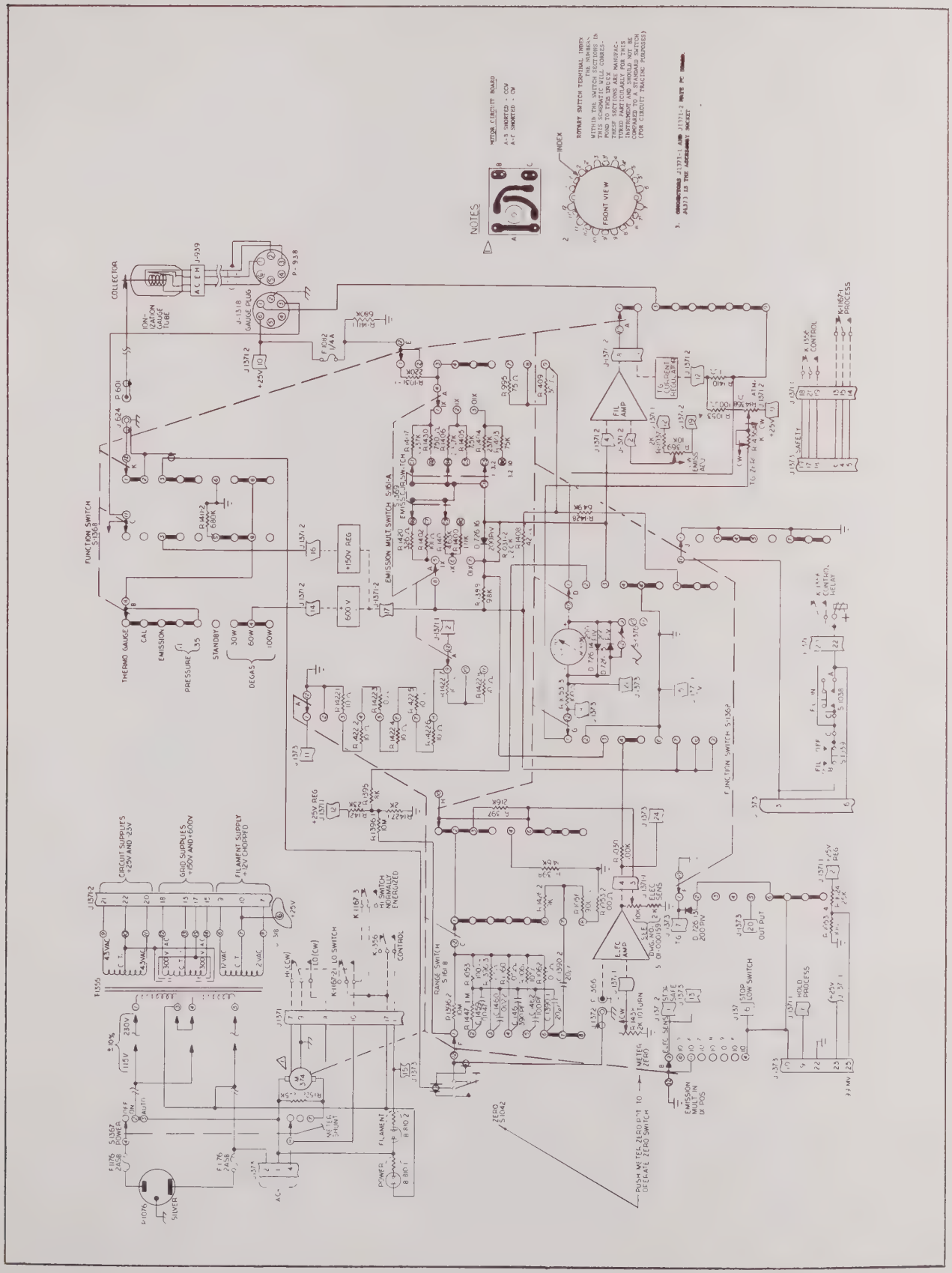


Figure 1. Ionization Gauge Controller functional schematic.

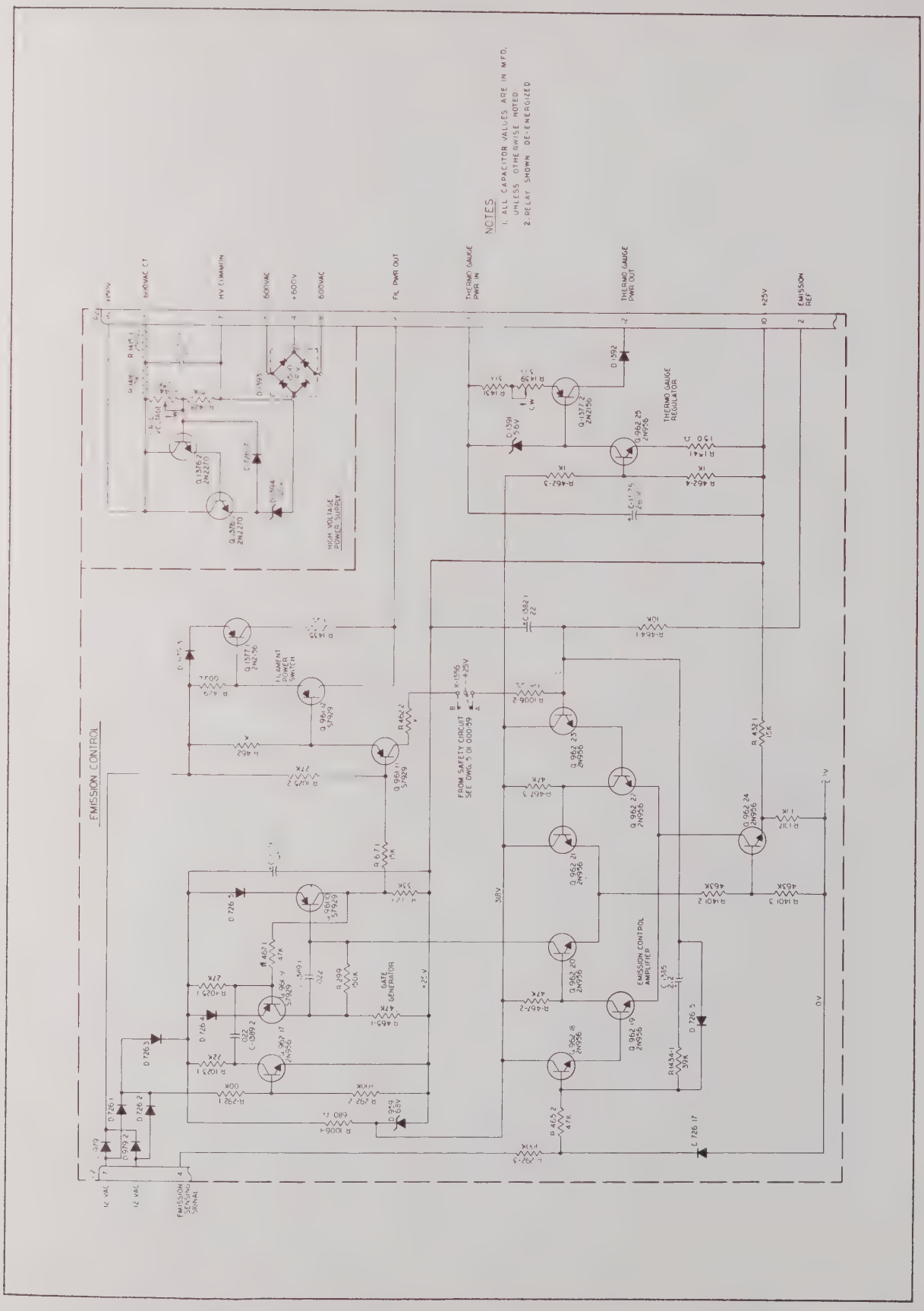


Figure 2. Grid supply and filament control schematic on printed circuit board.

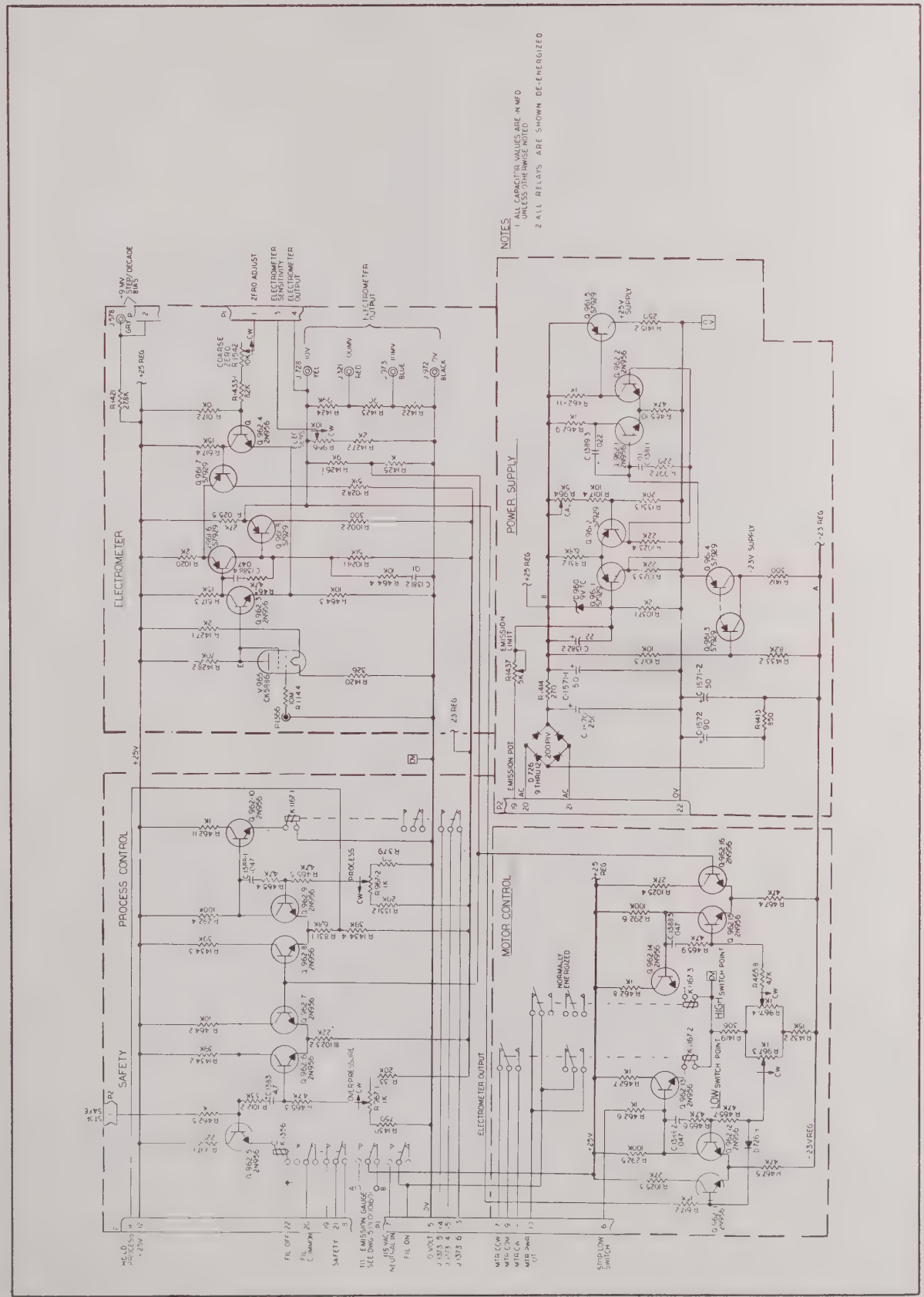


Figure 3. Transistor supply, electrometer and switching circuits schematic on printed circuit board.

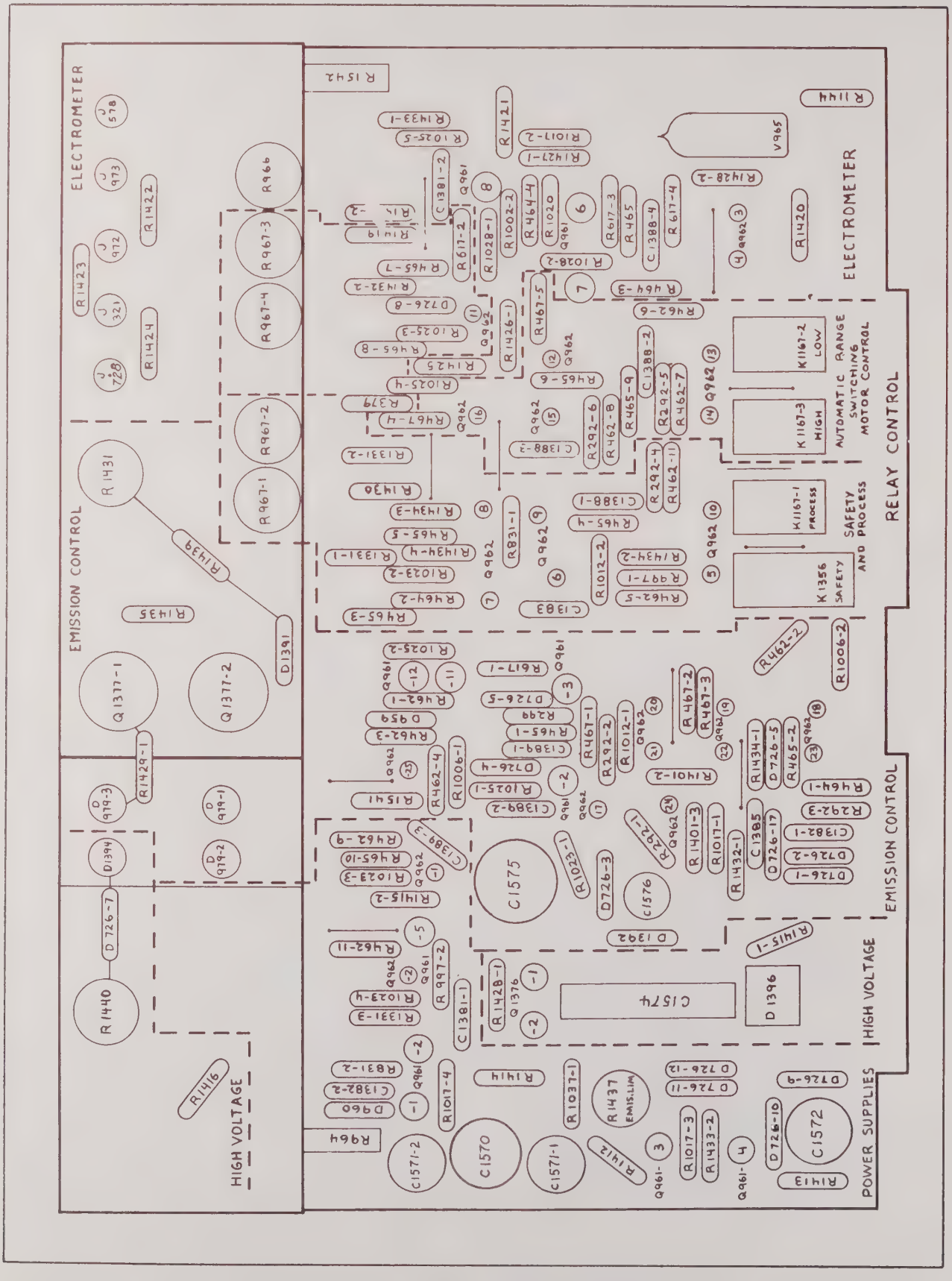


Figure 4. Location of components on printed circuit board assembly.

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CONDENSED OPERATING INSTRUCTIONS for Series 236 Model 02 IONIZATION GAUGE CONTROLLER

WARNING

Whenever the Controller is turned on, dangerous voltages are present inside the Controller and at the gauge and collector plugs. **DO NOT TOUCH THE GAUGE OR COLLECTOR LEAD TERMINATIONS WHEN THE POWER IS TURNED ON. LETHAL VOLTAGES ARE PRESENT AT THESE CONNECTIONS WHEN THE CONTROLLER FUNCTION SWITCH IS SET AT ANY DEGAS POWER SETTING.**

Once the Series 236 Controller has been installed, the Thermogauge calibrated, and appropriate adjustments checked in accordance with the detailed operating instructions, the following abbreviated procedures may be used:

MEASUREMENT OF 10^{-3} TORR AND LOWER

(1) Turn POWER Switch to ON. The neon indicator should come on. If Controller is equipped with Automatic Range Switching, turn POWER Switch to AUTO.
(2) Turn FUNCTION Switch to 11.
(3) Turn EMISSION MULTIPLIER to .1X.
(4) Turn RANGE Switch to 10^{-4}.
(5) If pressure is known to be sufficiently low, depress FILAMENT ON button. Filament should glow orange, and neon indicator above Filament Switches come on.
(6) Make sure that the pressure indication is reasonable.
(7) Turn FUNCTION Switch to EMIS. Adjust emission current as desired.
(8) Return FUNCTION Switch to 3.5 or 11 pressure position as is appropriate.

TO FOLLOW PUMP DOWN

(1) Turn POWER Switch to ON—indicator should light.
(2) Turn FUNCTION Switch to THERMO GAUGE (RANGE switch **not** to SENSITIVITY).
(3) Press FILAMENT ON button—indicator should light.
(4) Meter should read within ATMOS block after 60 seconds of equilibration.
(5) Start pump down.
(6) When properly adjusted, the Thermo Gauge should indicate on scale readings for all pressures normally encountered in vacuum systems.

Degassing the tube

(1) Be sure that the system pressure is 10^{-5} Torr or below.
(2) Be sure that personnel are clear of the tube and its leads.

LETHAL VOLTAGES ARE PRESENT WHEN FUNCTION SWITCH IS IN DEGAS POSITIONS.

(3) Turn FUNCTION Switch to 30 Watt DEGAS position.
(4) If tube is suspected of being very dirty, set EMISSION CURRENT ADJUST to Counterclockwise limit.
(5) Press FILAMENT ON button.
(6) If no bluish glow discharge appears, after a few minutes, increase degas power to the desired value. **WARNING:** Some gauge tubes can be damaged by excessive degas power.
(7) Decrease DEGAS power to 30 Watts for a few minutes when ending the degassing.
(8) Turn FILAMENT OFF and turn FUNCTION Switch out of DEGAS position.

GRANVILLE-PHILLIPS COMPANY

VACUUM EQUIPMENT

FOR USE FROM ATMOSPHERIC
TO THE
LOWEST PRESSURES ATTAINABLE

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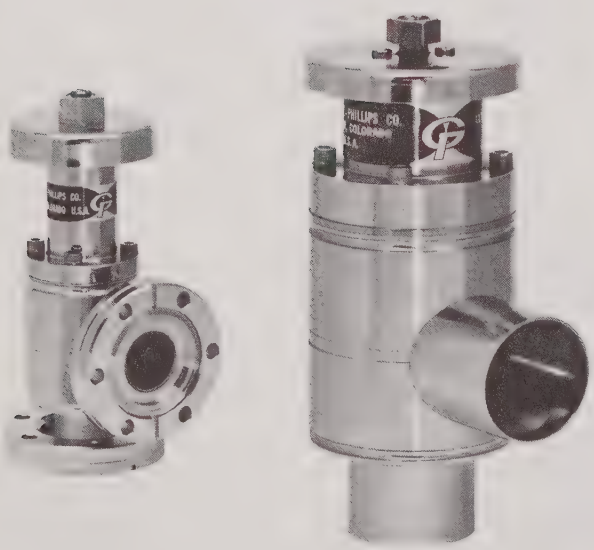
INSTALLATION AND OPERATING INSTRUCTIONS
For
Series 204, 1 Inch and Series 205, 2 Inch
GOLD SEAL ULTRA-HIGH VACUUM VALVES



1. IMPORTANT PRECAUTIONS

These Gold Seal Ultra-High Vacuum Valves are precision instruments manufactured under critical control to produce results which are orders of magnitude better than valves with organic seals. Successful use is dependent upon strict adherance to the procedures specified in these instructions. The metal-to-metal seal is particularly susceptible to damage by excessive temperatures, scratches, foreign particles, improper use, and careless bakeout procedures. However, properly cared for and used in accordance with the following suggestions, these valves will provide long and reliable service.

DO NOT remove the valve from its container until these instructions are understood.

DO NOT remove the port covers until the valve is mounted and ready to be connected to the vacuum system so contaminants will not enter the valve.

DO NOT support the valve by the valve ports only. Do not weld directly to the valve body, or tighten the mounting U-bolts excessively.

DO NOT apply more torque than necessary to produce a closing seal.

2. DESCRIPTION

2.1 COMPONENTS

These valves consist of a non-bakeable Driver Assembly and a bakeable Valve Body Assembly. The Driver Assembly controls valve conductance. The valve is held in the open position during bakeout by a Bakeout Pin. Stainless steel Mounting Brackets, Part No. 204 004 and Part No. 205 008, are available and permit mounting the valves in a variety of positions. Figs. 1 and 2 identify and show the proper location of all valve components. Fig. 4 shows mounting dimensions.

2.2 DESIGN AND CONSTRUCTION DETAILS

The valve seal is produced by compressing a very thin film of gold, carried on a precision knife edge of the Nosepiece, against a smooth, flat sealing surface in the Valve Body.

This unique seal depends on **strict cleanliness and proper closing thrusts** for its continued dependability. In routine tests, stock Series 204 and 205 Gold Seal Valves have been sealed mass spectrometer leak tight over 1000 consecutive times without evidence of seal deterioration.

The Nosepiece motion seal in the Valve Body Assembly is provided by the compact, welded, stainless steel Bellows which permits the Nosepiece of the Series 204 valve to

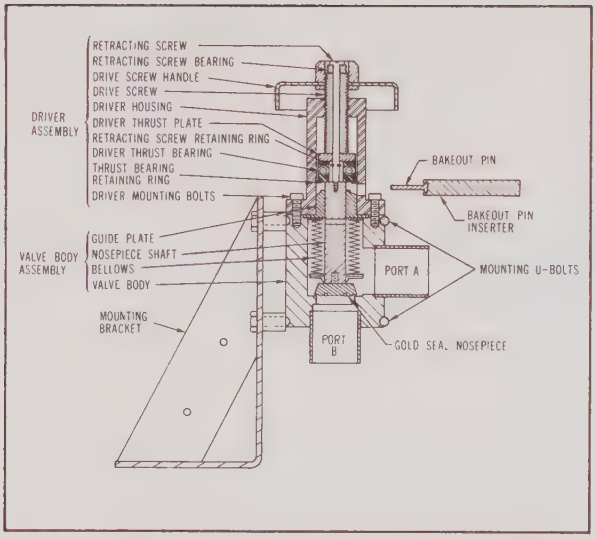


Figure 1. Sectional View of Series 204, 1 Inch Gold Seal Valve

be retracted approximately ¾ inch from the sealed position. The Nosepiece of the Series 205 valve can be retracted approximately 1½ inches from the sealed position.

3. INSTALLATION

3.1 CLEANLINESS

Keep the entire valve as clean as possible at all times. Do not remove the port covers until the valve is ready for installation in the vacuum system. Always keep the components in clean polyethylene bags when not in use. Contamination such as dust, dirt, film, lint, oxide scale, glass chips, metal chips, and corrosive materials can permanently damage the valve. Every known case of failure of valves to seal properly has been caused by contamination of the valve seal or contamination of the Driver Assembly lubricant, causing insufficient sealing force. For this reason, pass only clean, dry gas through the valve and keep the Driver Assembly clean.

3.2 MOUNTING

3.2.1. General

The valves may be mounted rigidly in any position using a Granville-Phillips Mounting Bracket or similar mounting device as shown in Fig. 4. The valve should NOT be supported solely by its port connections wherever possible, and welds should not be made to the Valve Body in any instance. Do not tighten the Mounting U-bolts excessively or the valve may be deformed and ruined.

Arrange the valve with other system components to be attached so that they will be in good alignment when the connections are made. When installing, be sure to leave adequate clearance for removal of the Driver Assembly and installation of the Bakeout Pin for bakeout.

3.2.2 Flange Connections

Granville-Phillips' rotatable CuSeal* Flanges are provided on all flanged valves as standard equipment. CuSeal* is Granville-Phillips' name for UHV flanges manufactured under license from Varian Associates, Inc. which are compatible with ConFlat** Flanges. CuSeal* Flanges will also mate with most other types of copper gasketed flanges supplied by major manufacturers.

A new, clean OFHC copper gasket must be inserted between each pair of mating flanges during installation. Take care not to mar the gasket surfaces. Lubricate the flange bolt threads and heads with a high temperature thread lubricant such as Jet Lube SS30 (manufactured by Jet Lube Inc., 3093 N. California St., Burbank, California) for increased bolt efficiency for making the flange seal and for prevention of galling upon bolt removal. Insert the flange bolts and tighten them evenly until the surfaces of both flanges are in contact. Use only Type 18-8 Stainless Steel bolts for connecting the flanges. Other bolt materials have different co-

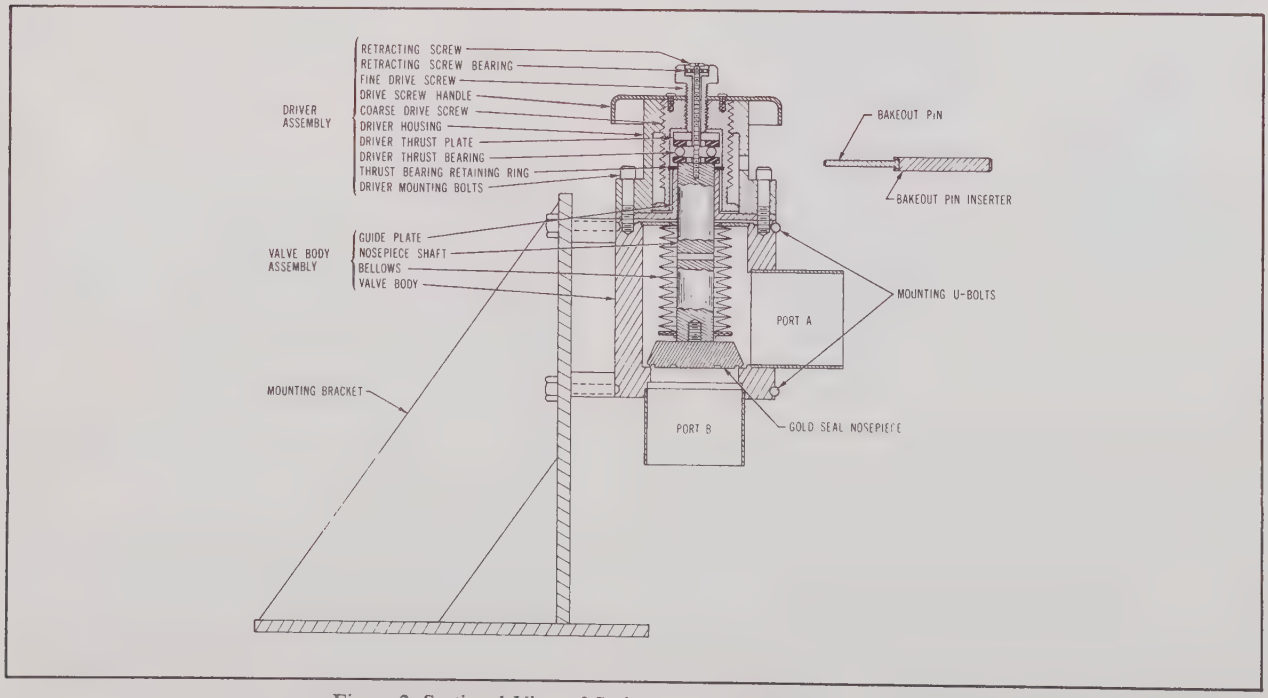


Figure 2. Sectional View of Series 205, 2 Inch Gold Seal Valve

*Trade Mark of Granville-Phillips Co.
**Trade Mark of Varian Associates, Inc.

efficients of expansion than the flanges and may not maintain a good seal during temperature cycling. Refer to Data Sheet 204-1 for Part Numbers of bolt, nut, and washer sets.

Properly installed flange connections will remain leak free through many ultra-high vacuum bakeouts to 450°C, if not subjected to extreme mechanical stresses.

3.2.3 Welding Connections

Welding connections are 1.00 inch o.d. x 0.035 inch wall on the Series 204 valve and 2.00 inch o.d. x 0.035 inch wall on the Series 205 valve. Port connections are Type 304 Stainless Steel which welds readily to other Series 300 Stainless Steel except for the free machining grades. It is important that an inert atmosphere inside the valve be maintained in all welding operations to prevent the formation of an oxide scale which might enter the valve and cause failure of the valve seal.

3.2.4 Glass Connections

Welding Kovar-glass connections directly to valve ports is not recommended on these valves since Nosepiece removal through this type connection is not practical. It is suggested that connections to glass systems be made through one of the Flanged Glass Seals offered in Data Sheet 214-1. These Glass Seals are flanged to mate with any Series 204 or 205 flanged valve and may be glassed directly to Corning Type 7740 Pyrex or its equivalent.

Flanged Glass Seals with metal bellows are desirable in reducing the stresses commonly encountered in glass or glass-metal systems. These seals are available in Flex-Pyrex and Non-collapsing Flex-Pyrex styles.

To prevent the collapse of large metal bellows due to atmospheric pressure and the resultant damage to system components from stresses, it is recommended that the non-collapsing bellows style be used in systems where bellows collapsing could be a problem. See Data Sheet 214-1.

4. VALVE OPERATION

4.1 SERIES 204 VALVE (See Fig. 1)

4.1.1 Opening Valve

The Driver Assembly contains the fine pitch Drive Screw which turns in the Driver Housing. The Drive Screw is fitted with a ¾ inch hex head nut to permit unsealing with a wrench and is also fitted with the Drive Screw Handle for rapid opening by hand.

Open the valve by rotating the Drive Screw Handle counterclockwise as viewed from the handle end. This may require up to 14 ft. lbs. initially, depending upon the torque previously used to seal the valve. The valve is fully opened after approximately 29 full turns of the Drive Screw Handle. A built-in stop prevents opening the valve too far. Do not force the Drive Screw against the stop.

The conductance of the Series 204 valve may be varied smoothly and easily from about 10 liters/second to less than 10^{-13} liter/second.

4.1.2 Closing Valve

Close the valve by rotating the Drive Screw Handle clockwise with the fingers until it bottoms. Apply minimum torque to the ¾ inch hex head nut of the Drive Screw to obtain the desired seal. A torque wrench such as Granville-Phillips Part No. 214 113 must be used for reproducible torques and optimum life. See Table I for typical sealing torques.

4.2 SERIES 205 VALVE (See Fig. 2)

4.2.1 Opening Valve

The Driver Assembly contains the Coarse Drive Screw fitted with the Drive Screw Handle, to permit rapid opening and closing of the valve, and the Fine Drive Screw fitted with a ¾ inch hex head nut to apply the sealing thrust to the valve seal. A wrench is used on the hex head nut of the Fine Drive Screw to initially unseal the valve if required.

Open the valve by turning the Fine Drive Screw counterclockwise several turns to remove the sealing torque. This may require up to about 20 ft. lbs. initially to loosen the Fine Drive Screw, depending upon the amount of torque used to seal the valve. Turn the Drive Screw Handle by hand aproximately 9 full turns, counterclockwise, to fully open the valve. A built-in stop prevents opening the valve too far. Do not force the Coarse Drive Screw against the stop.

Conductance of the Series 205 valve may be varied smoothly and easily from approximately 60 liters/second to less than 10^{-13} liter/second.

4.2.2 Closing Valve

To close the valve, first retract the Fine Drive Screw until about 8 to 10 threads are visible and then rotate the Drive Screw Handle clockwise until it bottoms on the top of the Driver Housing.

CAUTION

Do not tighten the Drive Screw Handle more than finger tight!

Determine that the Fine Drive Screw is free while the Drive Screw Handle is bottomed on the Driver Housing. If this is not the case, retract the Fine Drive Screw another turn and retighten the Drive Screw Handle.

Apply minimum torque to the ¾ inch hex head nut on the Fine Drive Screw to obtain the desired seal. Use a torque wrench such as Granville-Phillips Part No. 214 114, or equal, for reproducible torques and optimum valve life. See Table I for typical sealing torques.

4.3 CLOSING TORQUES

A mass spectrometer leak tight seal was obtained at the time your valve was shipped from the factory by torquing the valve to the value written on the yellow inspection tag attached to your valve. Use this torque as a guide in adjusting your valve.

Table I shows the sealing torque required for typical valves for the two conditions stated. Thus, for example, once it has been determined that a particular Series 204 valve requires 7 and 11 ft. lbs., respectively, for the two conditions shown in Table I, this valve will continue to require these two values of torque except for improper valve care.

Closing torques will normally increase slightly with extended use. Torques higher than necessary will greatly shorten the life of the valve seal. If the valve will not seal at normal closing torques, the Drive Screw or Driver Thrust Bearing may be dirty or not well lubricated. This is the most common cause of failure of a valve to seal and can easily be remedied by cleaning and relubricating the Driver Assembly. Refer to Cleaning and Lubricating instructions in Paragraph 6.1 or 6.2.

VALVE CONDITION	SERIES 204 1 INCH VALVE	SERIES 205 2 INCH VALVE
Valve Seal exposed to atmosphere since last bakeout open.	5-8 ft. lbs.	8-12 ft. lbs.
Valve Seal retained at low pressure since last bakeout open.	10-14 ft. lbs.	14-20 ft. lbs.

Table I. Approximate Sealing Torques for a Typical Range of Gold Seal Valves

5. BAKEOUT PROCEDURES

5.1 PREPARATION FOR BAKEOUT

The Driver Assembly must be removed for high temperature bakeout during which time the valve is held in the open position by the Bakeout Pin. To prepare the valve for bakeout refer to Figs. 1 or 2 and proceed as follows:

5.1.1 Turn the Drive Screw Handle counterclockwise to the completely open position so that the hole in the side of the Driver Housing is visually in line with the hole in the Nosepiece Shaft. **NOTE:** Make certain the Fine Drive Screw of the Series 205 valve is loosened before the Drive Screw Handle is turned.

5.1.2 Insert the Bakeout Pin through the hole in the Nosepiece Shaft using the Bakeout Pin Inserter.

5.1.3 Turn the Drive Screw Handle clockwise and gently advance the Nosepiece Shaft until the Bakeout Pin is held firmly in place. Do not turn the Drive Screw Handle too much as the Bakeout Pin will be bent.

5.1.4 Unscrew and remove the Bakeout Pin Inserter.

CAUTION

Never remove the Retracting Screw unless the Bakeout Pin is securely in place. To do so will allow the Nosepiece to fall against the valve seat and destroy the knife edge seal.

5.1.5 Loosen the Retracting Screw completely to disengage the Driver Assembly from the Nosepiece Shaft.

5.1.6 Remove the four Driver Mounting Screws attaching the Driver Assembly to the Valve Body.

5.1.7 Lift off the Driver Assembly and immediately place it in a clean, new polyethylene bag to keep the driver mechanism free of dirt and other contaminants. **This precaution is extremely important.**

5.1.8 The valve is now fully open and ready for bakeout.

5.2 BAKEOUT

The valve should be baked at temperatures above 250°C only in the open position with the Driver Assembly removed. When open with the Driver Assembly removed, bakeout temperatures up to 450°C may be safely used if low pressures are maintained to minimize oxidation of the interior stainless steel surfaces.

The valve may be baked with the Driver Assembly attached and in the closed position at temperatures not exceeding 250°C. Both sides of the valve seal must be protected by low pressure or an inert atmosphere during these bakeout procedures.

When baking the valve in the open position at temperatures between 150°C and 250°C, the Driver Assembly should be removed to extend the driver lubricant life.

Temperatures should be raised slowly since large quantities of gas may be evolved during the initial stages of bakeout. Do not bake longer than necessary. Excessive baking will shorten the useful life of the valve. However, valves of this design have been baked at 450°C in non-corrosive atmospheres for several hundred hours without sign of seal deterioration.

5.3 AFTER BAKEOUT

After the valve has cooled, the Driver Assembly is replaced as follows:

5.3.1 Turn the Drive Screw Handle counterclockwise so that the Driver Assembly is in the full open position. Refer to Section 4, Valve Operation. If the Driver Assembly is attached to the Valve Body with the drive mechanism not fully retracted, the Bakeout Pin will be sheared on the Guide Plate.

5.3.2 Carefully place the Driver Assembly on the Valve Body Assembly with the hole in the Driver Housing in line with the threaded end of the Bakeout Pin.

5.3.3 Install and tighten the four Driver Mounting Screws.

5.3.4 Gently turn the Drive Screw Handle clockwise until the Drive Screw and Driver Thrust Bearing bottom on the Nosepiece Shaft. On the Series 205 valve, the Fine Drive Screw should also be carefully turned clockwise until it bottoms if it was not already bottomed by turning the Drive Screw Handle.

5.3.5 Engage the Nosepiece Shaft with the Retracting Screw and tighten the Retracting Screw securely, but do not use excessive force.

5.3.6 Engage the Bakeout Pin with the Bakeout Pin Inserter.

5.3.7 Gently turn the Drive Screw Handle counterclockwise until the Bakeout Pin is free, and remove the Bakeout Pin.

5.3.8 The valve is now reassembled in the open position and ready for use.

6. VALVE MAINTENANCE

6.1 CLEANING AND LUBRICATING THE DRIVER ASSEMBLY (Series 204)

6.1.1 Disassembly (See Fig. 1)

6.1.1.1 Remove the Driver Assembly as described in Paragraph 5.1, Preparation for Bakeout.

6.1.1.2 Remove the Thrust Bearing Retaining Ring and Driver Thrust Bearing from the Driver Housing.

6.1.1.3 Remove the Retracting Screw Retaining Ring from the Retracting Screw, and remove the Retracting Screw and Retracting Screw Bearing from the Drive Screw.

6.1.1.4 Remove the Driver Thrust Plate from the Driver Housing. The Driver Thrust Plate is a close fit in the Driver Housing and tends to cock in the Driver Housing so that it will not freely drop out. With the Driver Housing held upright, insert the Retracting Screw into the Driver Thrust Plate through the bottom of the Driver Housing and rapidly oscillate it sideways. The Driver Thrust Plate will then fall out of the Driver Housing.

6.1.1.5 Unscrew the Drive Screw from the Driver Housing.

6.1.1.6 The parts are now ready for cleaning and lubricating.

6.1.2 Cleaning

6.1.2.1 Vigorously scrub all threads with a brush while rinsing with trichlorethylene or trichlorethane.

6.1.1.2 Clean all parts except the Driver Housing (which bears a label) in an ultra-sonic degreaser. If one is not available, wash and scrub all parts with a non-oil base solvent until completely clean. Recommended solvents are trichlorethylene or trichlorethane. Do not use oily base or other solvents which leave a residual film on the parts.

6.1.2.3 Air dry all parts in a dust free atmosphere. Do not dry the parts by rubbing with any type of absorbent material.

6.1.3 Lubricating

6.1.3.1 The recommended lubricant for these valves is molybdenum disulfide (Molykote®, Type G, Alpha-Molykote Corporation, Stamford, Connecticut). DO NOT use light oils, greases, or other materials which may enter the Bellows in the Valve Body Assembly and cause damage during subsequent bakeouts. Graphite is completely unsuitable.

6.1.3.2 Do not overlubricate. Use amounts that will not clump when the parts are replaced in the Driver Housing. Lubricate the following parts with a thin coat of molybdenum disulfide:

Drive Screw (Series 204 Valve)
Fine Drive Screw (Series 205 Valve)
Coarse Drive Screw, external threads (Series 205 Valve)
Driver Thrust Bearing
Driver Mounting Bolts
Retracting Screw Bearing (Series 205 Valve)

6.1.4 Reassembly (See Fig. 1)

6.1.4.1 Install the Drive Screw through the top of the Driver Housing.

6.1.4.2 Install the Retracting Screw Bearing and the Retracting Screw in the top of the Drive Screw. Hold the Retracting Screw with a finger, turn the Driver Assembly upside down, install the Driver Thrust Plate and install the Retracting Screw Retaining Ring, making certain it is securely seated in its slot on the Retracting Screw.

6.1.4.3 Install the Driver Thrust Bearing into the Driver Housing and install the Thrust Bearing Retaining Ring just above the Bakeout Pin hole in the Driver Housing as shown in Fig. 1.

6.1.1.4 Install the assembled Driver Assembly on the Valve Body as described in Paragraph 5.3, After Bakeout.

6.1.4.5 The valve is now completely reassembled and ready for use.

6.2 CLEANING AND LUBRICATING THE DRIVER ASSEMBLY (Series 205)

6.2.1 Disassembly (See Fig. 2)

6.2.1.1 Remove the Driver Assembly as described in Paragraph 5.1, Preparation for Bakeout.

6.2.1.2 Remove the Retracting Screw and Retracting Screw Bearing from the Fine Drive Screw.

6.2.1.3 Unscrew and remove the Fine Drive Screw from the Coarse Drive Screw.

6.2.1.4 Remove the Thrust Bearing Retaining Ring. The Driver Thrust Bearing and the Driver Thrust Plate will then fall out of the Driver Assembly.

6.2.1.5 Remove the two screws attaching the Drive Screw Handle to the Coarse Drive Screw, and remove the Drive Screw Handle from the Coarse Drive Screw.

6.2.1.6 Turn the Coarse Drive Screw clockwise (viewed from the top) with fingers, and remove it through the bottom of the Driver Housing.

6.2.1.7 The parts are now ready for cleaning and lubricating.

6.2.2 Cleaning

The procedures for cleaning the Series 205 valve are the same as those prescribed for the Series 204 valve. Refer to Paragraph 6.1.2 for cleaning procedures.

6.2.3 Lubricating

The procedures for lubricating the Series 205 valve are the same as those prescribed for the Series 204 valve. Refer to Paragraph 6.1.3 for lubricating procedures.

6.2.4 Reassembly (See Fig. 2)

6.2.4.1 Install the Coarse Drive Screw through the base of the Driver Housing so that several threads show above the Driver Housing. Install the Drive Screw Handle on the Coarse Drive Screw and secure it with the two screws.

6.2.4.2. Install the Driver Thrust Plate and then the Driver Thrust Bearing. Push these parts inside the Coarse Drive Screw and install the Thrust Bearing Retaining Ring as shown in Fig. 2.

6.2.4.3 Install the Fine Drive Screw, leaving about 10 threads showing.

6.2.4.4 Install the Retracting Screw Bearing and the Retracting Screw into the Fine Drive Screw.

6.2.4.5 Turn the Drive Screw Handle counterclockwise to the full open position and install the assembled Driver Assembly on the Valve Body as described in Paragraph 5.3, After Bakeout.

6.2.4.6 The valve is now completely reassembled and ready for use.

6.3 INSTALLING NEW GOLD SEAL NOSEPIECE (See Fig. 3)

6.3.1 General

Note that the Nosepiece is not removable through a Kovar-Pyrex seal. The replacement nosepiece kit, Part No. 204 014 for Series 204 valves and 205 014 for Series 205 valves, contains a new Gold Seal Nosepiece and two pairs of tweezers. These tweezers are the only tools used in the replacement of the Nosepiece.

6.3.2 Removal of Valve from System

6.3.2.1 Open the valve (Paragraphs 4.1.1 or 4.2.1) and install the Bakeout Pin (Steps 5.1.1 and 5.1.2).

6.3.3 Removal of Gold Seal Nosepiece

6.3.3.1 Lay the valve on its side on a clean work top and so there is room to look and work through both valve ports.

6.3.3.2 Thoroughly degrease both pairs of tweezers.

6.3.2.2 Tighten the Drive Screw Handle finger tight against the Bakeout Pin.

6.3.2.3 Disconnect both ports of the valve from the system and remove the valve.

6.3.2.4 Make certain all contamination is excluded from the valve during handling.

6.3.3.3 Insert one pair of tweezers into Port B and engage the tweezer prongs into the two indentations in the face of the Nosepiece as shown in Step **A** of Fig. 3. Do not damage the Nosepiece knife edge.

6.3.3.4 Turn the tweezers counterclockwise and gently loosen the Nosepiece threads. Maintain pressure on the tweezers to securely hold the Nosepiece and continue to loosen the Nosepiece until it is free.

6.3.3.5 While holding the Nosepiece securely with the first pair of tweezers, carefully insert the second pair of tweezers through Port A and clamp them around the threaded portion at the rear of the Nosepiece as shown in Step **B** of Fig. 3.

6.3.3.6 While firmly holding the threaded portion, release the first pair of tweezers from the indentations in the face of the Nosepiece, and remove them from Port B.

6.3.3.7 Look into Port A and position the Nosepiece so that its maximum diameter will coincide with the inside diameter of the tubulation, and remove the Nosepiece through Port A as shown in Step **C** of Fig. 3. Note that the maximum diameter of the Nosepiece must be extracted on a diameter of the tubulation so that the valve is not damaged.

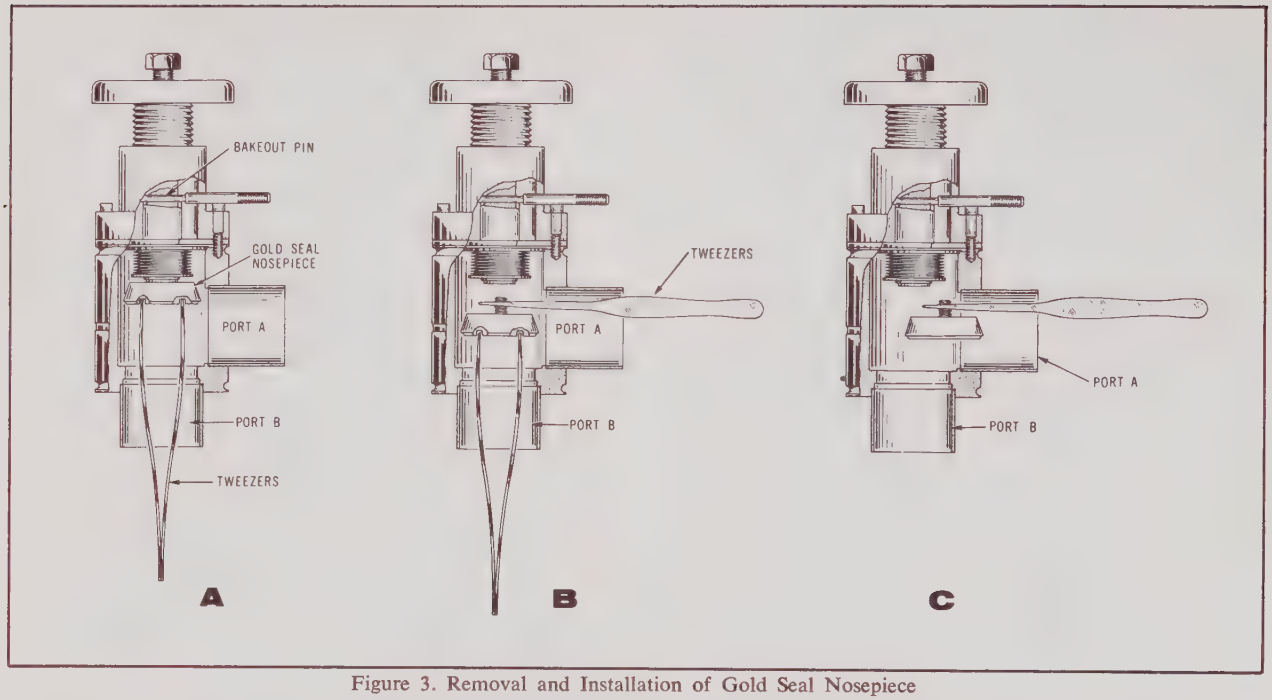


Figure 3. Removal and Installation of Gold Seal Nosepiece

6.3.4 Installation of Gold Seal Nosepiece

6.3.4.1 Make certain that both pairs of tweezers are clean, and degrease them if necessary.

6.3.4.2 Make certain that the valve is fully open and the Bakeout Pin is installed.

6.3.4.3 Lay the valve on its side on a clean work top and so there is room to look and work through both valve ports.

6.3.4.4 Carefully remove the new Gold Seal Nosepiece from its container. Using one pair of tweezers, firmly grasp the new Nosepiece by the threaded portion, with the tweezers perpendicular to the axis of the threads.

6.3.4.5 Line up the maximum diameter of the Nosepiece with the diameter of the Port A tubulation. Carefully insert the new Nosepiece into Port A as shown in Step **C** of Fig. 3, and position the threaded portion in line with the threads in the Nosepiece Shaft.

6.3.4.6 Insert the second pair of tweezers through Port B and engage the tweezer prongs into the two indentations in the face of the Nosepiece as shown in Step **B** of Fig. 3.

6.3.4.7 Apply pressure to the tweezers to securely hold the Nosepiece by the two indentations, release the first pair of tweezers, and remove them from Port A.

6.3.4.8 Push the threaded portion of the Nosepiece into the threads of the Nosepiece Shaft as shown in Step **A** of Fig. 3. Turn the Nosepiece clockwise until the threads engage. Continue to rotate the Nosepiece with the tweezers until it is finger tight, and then remove the tweezers.

CAUTION

Do not overtighten the Gold Seal Nosepiece. Do not permit the tweezers to slip out of the two indentations and hit the knife edge seal on the face of the Nosepiece. A slight nick in this knife edge will completely destroy the sealing qualities of the valve.

6.3.4.9 The valve is now ready for installation in the vacuum system.

6.4 VALVE STORAGE

When the valve must be stored for any length of time, close the valve to finger tight torque to protect the seal from contamination. Stopper the ports with rubber or plastic plugs, or cover them with aluminum foil. Corks are not suitable because of their tendency to break and crumble. Do not use tape on open port ends. Place the valve in a clean, new polyethylene bag when it is removed and not in use.

7. VALVE CHARACTERISTICS

7.1 WELDS

To insure uniform weld smoothness and freedom from both real and virtual leaks, all vacuum joints are inert gas welded on an automatic welder in all cases and are welded on the vacuum side in every case where possible. Each joint is tested immediately after welding on a helium mass spectrometer leak detector capable of detecting a leakage conductance of less than 1×10^{-13} liter/second. No detectable leaks are permitted.

7.2 MATERIALS

Metals in contact with vacuum are specially processed Types 304 and 347 Stainless Steel, and pure gold. No organic or high vapor pressure materials are in the vacuum enclosure.

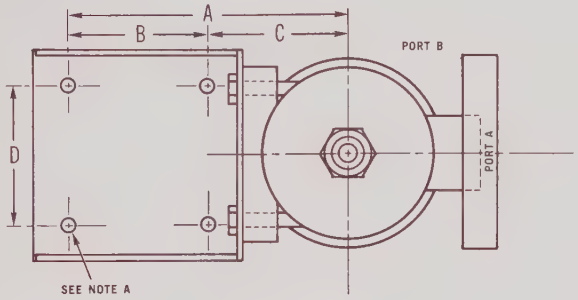
7.3 TEMPERATURE RANGE

The valve with Driver Assembly attached is designed to operate at temperatures to 250°C without damaging the valve seal or the Driver Assembly. With the Driver Assembly removed and the valve held in the open position by the Bakeout Pin, the valve is bakeable for prolonged periods to 450°C if low pressures are maintained. When closed and sealed, it may be baked repeatedly to 250°C. The valve is not designed to be baked out to higher temperatures for long periods in the closed position because the degree of diffusion welding depends on time and temperature, and at temperatures much above 250°C, rapid diffusion welding occurs.

7.4 CONDUCTANCE

Series 204 Valves. These valves have a fully opened conductance port to port of about 10 liters/second for air in the molecular flow region. When fully closed, the leakage conductance is less than 10^{-13} liter/second both before and after bakeout.

Series 205 Valves. These valves have a fully opened conductance port to port of about 60 liters/second for air in the molecular flow region. When fully closed, the leakage conductance is less than 10^{-13} liter/second both before and after bakeout.



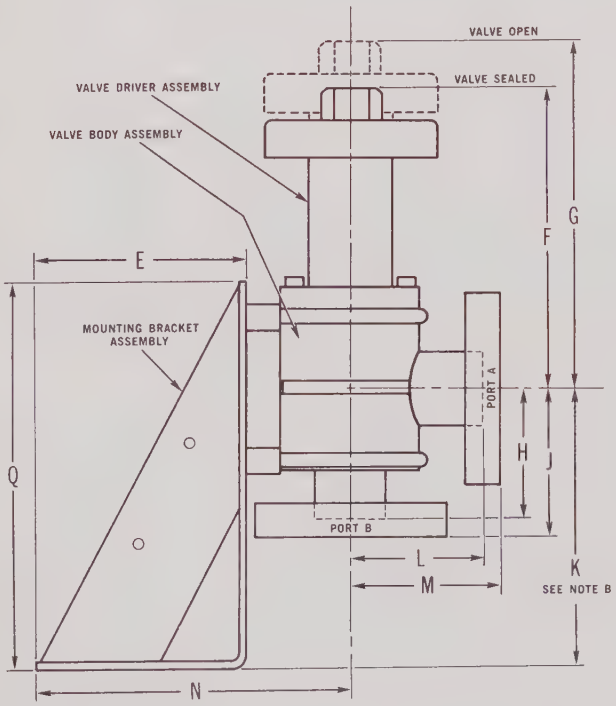
VALVE COMPLETE
TOP VIEW OF VALVE MOUNTED VERTICALLY

NOTE A

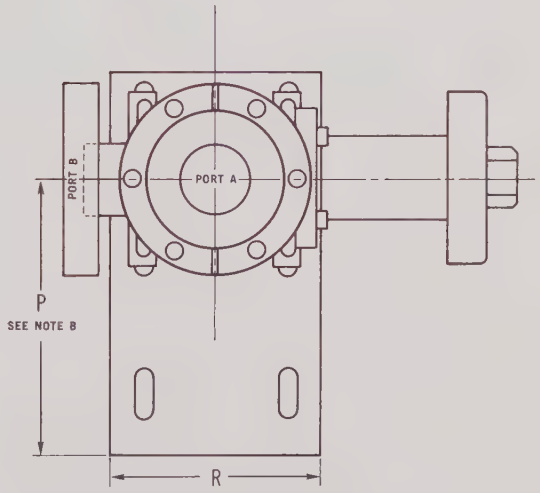
SERIES 204 VALVE—4 HOLES 7/32-INCH
SERIES 205 VALVE—6 HOLES 17/64-INCH

NOTE B

MOUNTING BRACKETS ALLOW POSITIONING OF VALVE WITHIN THE MAXIMUM AND MINIMUM DIMENSIONS SHOWN



VALVE COMPLETE
SIDE VIEW OF VALVE MOUNTED VERTICALLY



VALVE COMPLETE
FRONT VIEW OF VALVE MOUNTED HORIZONTALLY

DESCRIPTION	DIMENSIONS - SHOWN IN INCHES															
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R
SERIES 204 VALVE	4-7/64	2	2-7/64	2	3	4	4-57/64	1-7/8	2-9/64	3-23/32 to 4-1/4	1-7/8	2-9/64	4-1/2	3-45/64 to 4-1 4	5-1/2	3
SERIES 205 VALVE	7-15/16	4-11/16	3-1/4	3-3/8	5-3/4	5-3/32	6-45/64	3	3-3/8	6-3/16 to 7-3/16	3	3-3/8	8-1/4	6-5/32 to 7-13/64	9-3/16	4

Figure 4. Mounting Dimensons for Series 204 and Series 205 Gold Seal Valves

8. SPECIFICATIONS

Materials

Seal	Pure gold and specially processed Type 304 Stainless Steel
All other interior surfaces	Specially processed Type 304 Stainless Steel

Physical Data

Bakeout temperatures	450°C, valve open, driver removed; 250°C valve open or closed, driver installed	
Seal deformation vs number of closures	Negligible	
Increase in closing torque vs number of closures	Negligible	
Nosepiece replacement	May be changed in the field with the Replacement Gold Seal Nosepiece Kit.	
	Series 204	Series 205
	1 Inch	2 Inch
Minimum flow path, flange to flange, when fully open	4.28 in.	6.75 in.
Maximum conductance for dry nitrogen at 25°C	10 liters/sec.	60 liters/sec.
Leakage conductance when fully closed	10^{-13} liter/sec.	10^{-13} liter/sec.
Nominal closing torque without bakeout	5-8 ft.lbs.	8-12 ft.lbs.
Nominal closing torque after bakeout	10-14 ft.lbs.	14-20 ft.lbs.

Standard connections ..... Type 304 Stainless Steel or CuSeal* flanges. Pyrex and Flex-Pyrex connections welded to the valve ports are not recommended because their inside diameter is too small to permit replacement of the gold seal. If you need glass connections, we suggest they be made with a Granville-Phillips' Flanged Glass Seal as shown in the Parts and Accessories section of this data sheet.

*CuSeal is Granville-Phillips' name for UHV flanges manufactured under license from Varian Associates which are compatible with ConFlat flanges. CuSeal flanges are guaranteed to meet or exceed the performance of any copper seal flange now available.

WARRANTY

The Company warrants that each item of merchandise sold by it is free from defective workmanship or material and it will replace or repair any item found to be defective in workmanship and/or material upon return of the same to the company office at Boulder, Colorado. The liabilities of the company arising out of supplying said products or their use, whether on said warranties or otherwise, shall in no case exceed the cost of correcting defects in the product. No other warranty, expressed or implied, is assumed or will be assumed.

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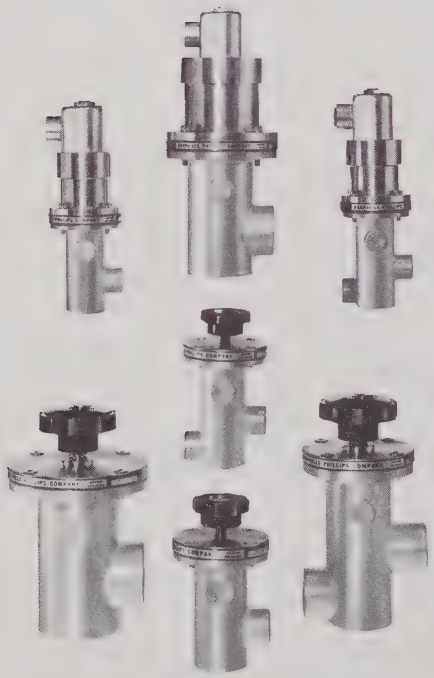
INSTALLATION, OPERATION and MAINTENANCE INSTRUCTIONS For Series 257 and 258 BELLOWS SEALED HIGH VACUUM VALVES



1. UNPACKING

1.1 The best of containers, packing material, and methods were used in packing this equipment for shipment. Even so, careless or rough handling in transit may have caused damage.

1.2 Before opening the carton, please inspect for external shipping damage. Open the carton and inspect the valve for damage. Whether the damage is of a concealed or apparent nature, the company that **made** the delivery must be notified within 15 days of delivery in accordance with Interstate Commerce Commission regulations.

2. GENERAL

2.1 All information necessary for the installation, operation, and maintenance of the Series 257 and Series 258 valves is contained in these instructions. Compliance with the instructions is necessary in order to assure long, trouble-free operation from your valve. Refer to Figure 1 for identification and location of all parts.

2.2 The following general precautions should be observed while performing installation and maintenance operations.

2.2.1 Remove the complete Driver Assembly before attempting to braze or solder the port connections.

2.2.2 Do not flex the Bellows when the Driver Assembly is removed from the Valve Body. This action may cause cracks in the Bellows.

2.2.3 Never immerse the Viton O-rings in solvents. To clean the O-rings, coat them with a small amount of diffusion pump oil and wipe them dry with a lint free tissue.

2.2.4 Do not use more torque than is necessary to produce a leak tight seal.

3. INSTALLATION

3.1 MECHANICAL CONNECTIONS (ALL MODELS)

3.1.1 These valves are designed to operate in any position; however, it is recommended that the Bellows mechanism be on the higher pressure side of the system when the valve is closed. To facilitate mounting air operated models, the Solenoid Assembly can be positioned throughout 360° in 90° increments. Make sure the valve is mounted with adequate clearance to permit removal and replacement of the complete Driver Assembly. See Figure 2 for mounting dimensions.

3.1.2 Open manually operated valves approximately ¼ inch and remove the Valve Handle by loosening the Handle Set Screw in the Valve Handle. The disassembly of air operated models may proceed with the valves in the closed position.

3.1.3 Remove the four Driver Mounting Screws securing the Driver Plate to the Valve Body and carefully lift the Driver Assembly up and out of the Valve Body. Carefully preserve the Bellows-Body O-ring and take care not to damage the Valve Seal O-ring or the Bellows.

3.1.4 Follow standard procedures for soldering or brazing tubulations to the ports of the Valve Body, taking care that the valve seat in the Valve Body is not damaged.

3.1.5 Thoroughly clean the Valve Body to remove all traces of solder flux and foreign matter. Carefully inspect the sealing surfaces for the Valve Seal O-ring and the Bellows-Body O-ring to insure they are undamaged and clean.

3.1.6 Replace the Bellows-Body O-ring. Carefully position the Driver Assembly on the Valve Body and line up the screw holes. Install the Driver Mounting Screws and tighten them securely.

3.2 SERVICE CONNECTIONS (AIR OPERATED MODELS ONLY)

3.2.1 Connect a compressed air supply of 60 to 125 psig to the inlet port of the Air Cylinder with ⅛ inch pipe fittings. Use Teflon tape or the equivalent on male pipe threads to prevent leakage or seizing of the threads. It is important that the Solenoid be protected from dirt, etc. in the air line; therefore, an air filter and microfog lubricator should be installed in the air supply line. The recommended air pressure for optimum valve operation is from 75 to 80 psig.

3.2.2 Connect electrical power to the leads from the Solenoid. Valves are normally supplied for 115 volts, 60 cycles. The name plate on the Solenoid states the characteristics of the required power supply.

NOTE

Valves are "normally closed", i.e., the valve is in the closed position when the Solenoid is de-energized.

4. OPERATION

4.1 Open manually operated valves by turning the Valve Handle counter-clockwise until free action stops. When closing the valve, DO NOT use force. Apply only sufficient torque to provide a leak tight seal.

4.2 Open air operated valves by applying power to the Solenoid.

5. DISASSEMBLY (See Figure 1)

5.1 Open manually operated valves approximately ¼ inch and remove the Valve Handle by loosening the Handle Set Screw. The disassembly of air operated models may proceed with the valve in the closed position.

5.2 Remove the four Driver Mounting Screws securing the Driver Plate to the Valve Body and carefully lift the Driver Assembly up and out of the Valve Body.

5.3 If only the Valve Seal O-ring or the Bellows-Body O-ring are to be replaced, do not proceed with further disassembly.

5.4 On manually operated models, unscrew the Manual Driver Plate from the Manual Shaft. On air operated models, separate the Solenoid Assembly from the Shaft-Nosepiece Assembly by pulling the Solenoid up and off of the Piston Cup.

5.5 On manually operated models insert the Disassembly Tool inside the Bellows to hold the Nylon Shaft Nut, and unscrew the Nosepiece from the Nylon Shaft Nut. Separate the Nosepiece and the Bellows. On air operated models, unscrew the Nosepiece from the Solenoid Shaft while holding the Piston Cup, and remove the Nosepiece, Thrust Washer, and Bellows.

5.6 The valve is now disassembled to a point where the Piston Cup on air operated models, all O-rings and the Bellows can be replaced.

5.7 Carefully remove the O-rings from their grooves. DO NOT use a sharp or pointed instrument to lift the O-rings from grooves as this may permanently damage the O-ring or the O-ring groove.

6. CLEANING AND INSPECTION

6.1 Cleanliness is of the utmost importance in high vacuum systems and will insure continued trouble-free operation of the valves. Accumulation of dirt and foreign matter on the seat of the Valve Body and on the Valve Seal O-ring can cause loss of performance. Aging of O-rings and loss of elasticity can also cause improper sealing. If leakage should be detected, check for dirt accumulation on the Valve Body seat and around the Valve Seal O-ring.

6.2 The Valve Seal O-ring and the seat of the Valve Body can be cleaned without removing the valve from the system by following the procedures in Paragraph 5, DISASSEMBLY.

6.3 Metal parts of the valve should be cleaned with Alconox and rinsed thoroughly with methyl alcohol.

6.4 Examine all O-rings carefully before reinstalling them. If only minute leaks were present in the seals, apply a very thin, almost invisible film of Apiezon N Grease or Dow Corning 705 Pump Oil. If noticeable gouges, cracks, distortions, or other imperfections are noticed in the O-rings, install new O-rings.

NOTE

Do not install a dry O-ring. Always coat the O-rings lightly with Apiezon N Grease or Dow Corning 705 Pump Oil before installation.

7. REASSEMBLY (See Figure 1)

7.1 Reinstall all O-rings after preparing them as instructed in Paragraph 6 above.

7.2 On air operated models, install the Thrust Washer with its lip into the Shaft Spring on the Solenoid Shaft.

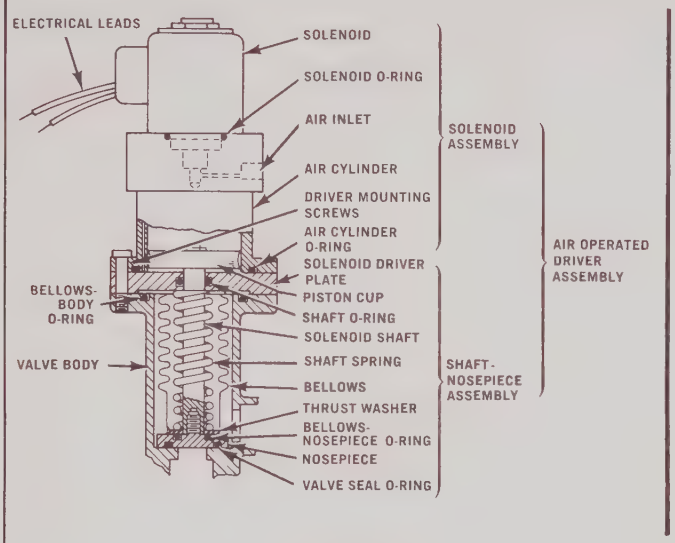
7.3 Place the Bellows over the Shaft.

7.4 Install the Bellows-Nosepiece O-ring and the Nosepiece, and tighten the Nosepiece securely. Use the Disassembly Tool to hold the Nylon Shaft Nut on manually operated valves. On air operated valves the Piston Cup must be held.

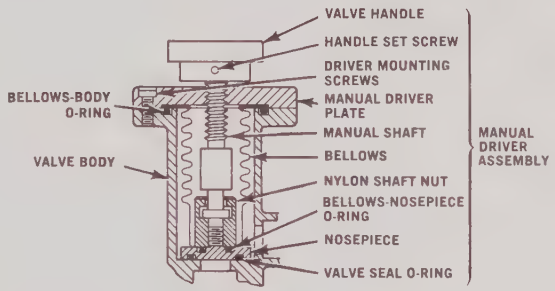
7.5 On manually operated valves, screw the Manual Driver Plate on the Manual Shaft. On air operated valves, carefully fit the Solenoid Assembly over the Piston Cup, taking care not to distort or otherwise damage the sealing lips of the Piston Cup. Gently push the Solenoid Assembly down until the Air Cylinder is snug against the Solenoid Driver Plate. Rotate the Solenoid Assembly so that the mounting holes of the Air Cylinder are aligned with the mounting holes of the Solenoid Driver Plate.

7.6 Install the Driver Assembly into the Valve Body, align the holes for the Driver Mounting Screws, and secure the assembly with four Driver Mounting Screws.

7.7 Reinstall the Valve Handle on manually controlled valves.



AIR OPERATED



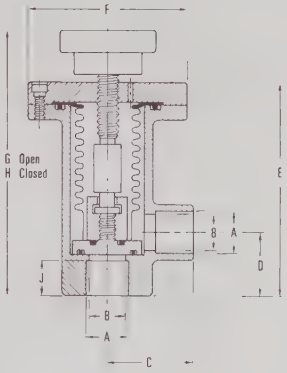
MANUAL CONTROL

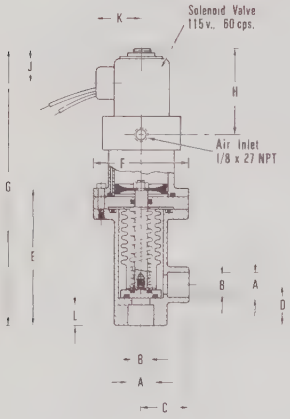
REPLACEMENT PARTS

DESCRIPTION	CATALOG NO.
Manual Driver Assembly complete with bellows, nosepiece and Viton O-rings for valves 257 102, 257 104, 257 106, 258 102, 258 104 and 258 106	257 211
Manual Driver Assembly complete with bellows, nosepiece and Viton O-rings for valves 257 108 and 258 108	257 212
Manual Driver Assembly complete with bellows, nosepiece and Viton O-rings for valve 257 110	257 213
Air Operated Driver Assembly complete with solenoid, bellows, nosepiece and Viton O-rings for valves 257 202, 257 204, 257 206, 258 202, 258 204 and 258 206	257 214
Air Operated Driver Assembly complete with solenoid, bellows, nosepiece and Viton O-rings for valves 257 208 and 258 208	257 215
Air Operated Driver Assembly complete with solenoid, bellows, nosepiece and Viton O-rings for valve 257 210	257 216
Bellows for valves 257 102, 257 104, 257 106, 258 102, 258 104, 258 106, 257 202, 257 204, 257 206, 258 202, 258 204 and 258 206	257 217
Bellows for valves 257 108, 258 108, 257 208 and 258 208	257 218
Bellows for valves 257 110 and 257 210	257 219
Viton O-ring for valve seal on valves 257 102, 257 104, 257 106, 258 102, 258 104, 258 106, 257 202, 257 204, 257 206, 258 202, 258 204 and 258 206	257 220
Viton O-ring for valve seal on valves 257 108, 258 108, 257 208 and 258 208	257 221
Viton O-ring for valve seal on valves 257 110 and 257 210	257 222
Viton O-ring for bellows-body on valves 257 102, 257 104, 257 106, 258 102, 258 104, 258 106, 257 202, 257 204, 257 206, 258 202, 258 202 and 258 206	257 223
Viton O-ring for bellows-body on valves 257 108 and 258 108	257 224
Viton O-ring for bellows-body on valves 257 208 and 258 208	257 225
Viton O-ring for bellows-body on valves 257 110 and 257 210	257 226
Viton O-ring for bellows-nosepiece seal on all valve models	257 227
Viton O-ring for air cylinder on valves 257 202, 257 204, 257 206, 258 202, 258 204 and 258 206	257 228
Viton O-ring for air cylinder on valves 257 208 and 258 208	257 229
Viton O-ring for air cylinder on valves 257 210	257 230
Buna Quad shaft O-ring for all air operated valves	257 231
Piston cup for valves 257 202, 257 204, 257 206, 258 202, 258 204 and 258 206	257 232
Piston cup for valves 257 208 and 258 208	257 233
Piston cup for valves 257 210	257 234
Disassembly Tool	214 486

Figure 1. Cross-sectional views of Manual and Air Operated Valves.

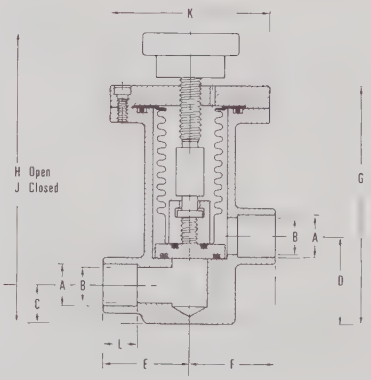
SERIES 257 – MANUAL CONTROL – RIGHT ANGLE VALVES									
CATALOG NO.	A	B	C	D	E	F	G	H	J
257 102	3/8	1/4	1-13/32	1-3/16	3-3/4	2-3/4	5-17/32	4-27/32	5/8
257 104	1/2	3/8	1-13/32	1-3/16	3-3/4	2-3/4	5-17/32	4-27/32	5/8
257 106	3/4	5/8	1-13/32	1-3/16	3-3/4	2-3/4	5-17/32	4-27/32	5/8
257 108	1-1/8	1	2-1/32	1-11/16	4-3/4	3-3/8	7-11/32	6-11/32	15/16
257 110	1-5/8	1-1/2	2	1-11/16	5-1/8	4-1/4	8-7/32	6-23/32	3/4

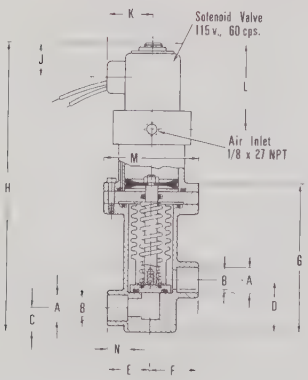




SERIES 257 – AIR OPERATED – RIGHT ANGLE VALVES											
CATALOG NO.	A	B	C	D	E	F	G	H	J	K	L
257 202	3/8	1/4	1-13/32	1-3/16	4	2-3/4	8-3/64	2-5/8	1-1/32	1-7/16	5/8
257 204	1/2	3/8	1-13/32	1-3/16	4	2-3/4	8-3/64	2-5/8	1-1/32	1-7/16	5/8
257 206	3/4	5/8	1-13/32	1-3/16	4	2-3/4	8-3/64	2-5/8	1-1/32	1-7/16	5/8
257 208	1-1/8	1	2-1/32	1-11/16	5	3-3/8	9-27/64	2-5/8	1-1/32	1-7/16	15/16
257 210	1-5/8	1-1/2	2	1-11/16	5-7/16	4-1/4	10-11/64	2-5/8	1-1/32	1-7/16	3/4

SERIES 258 – MANUAL CONTROL – IN-LINE VALVES											
CATALOG NO.	A	B	C	D	E	F	G	H	J	K	L
258 102	3/8	1/4	5/8	1-1/2	1-9/32	1-13/32	4-1/16	5-27/32	5-5/32	2-3/4	5/8
258 104	1/2	3/8	5/8	1-1/2	1-9/32	1-13/32	4-1/16	5-27/32	5-5/32	2-3/4	5/8
258 106	3/4	5/8	5/8	1-1/2	1-9/32	1-13/32	4-1/16	5-27/32	5-5/32	2-3/4	5/8
258 108	1-1/8	1	31/32	2-11/32	1-23/32	2-1/32	5-7/16	8	7	3-3/8	15/16





SERIES 258 – AIR OPERATED – IN-LINE VALVES													
CATALOG NO.	A	B	C	D	E	F	G	H	J	K	L	M	N
258 202	3/8	1/4	5/8	1-1/2	1-9/32	1-13/32	4-5/16	8-23/64	1-1/32	1-7/16	2-5/8	2-3/4	5/8
258 204	1/2	3/8	5/8	1-1/2	1-9/32	1-13/32	4-5/16	8-23/64	1-1/32	1-7/16	2-5/8	2-3/4	5/8
258 206	3/4	5/8	5/8	1-1/2	1-9/32	1-13/32	4-5/16	8-23/64	1-1/32	1-7/16	2-5/8	2-3/4	5/8
258 208	1-1/8	1	31/32	2-11/32	1-23/32	2-1/32	5-21/32	10-5/64	1-1/32	1-7/16	2-5/8	3-3/8	15/16

Figure 2. Dimensions for Series 257 and 258 Bellows Sealed Valves.

WARRANTY

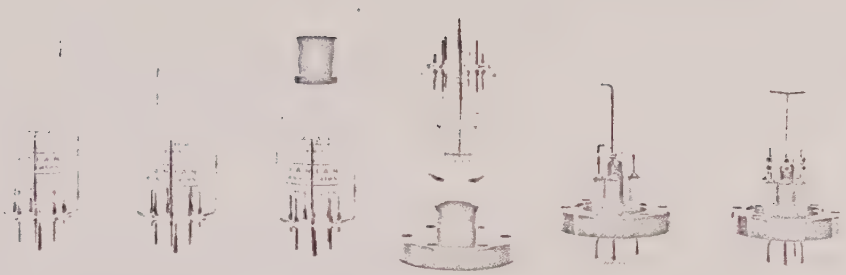
The Company warrants that each item of merchandise sold by it is free from defective workmanship or material and it will replace or repair any item found to be defective in workmanship and/or material upon return of the same to the company office at Boulder, Colorado. The liabilities of the company arising out of supplying said products or their use, whether on said warranties or otherwise, shall in no case exceed the cost of correcting defects in the product. No other warranty, expressed or implied, is assumed or will be assumed.

Printed in USA

IONIZATION GAUGE

INSTRUCTION SHEET

MODELS
UHV-12-K UHV-12-P
UHV-12-KF UHV-14
UHV-12-N UHV-24



Varian Ionization Gauges give accurate pressure measurement from 10^{-3} torr (mmHg) down to their x-ray limit, corresponding to a pressure indication of about 2×10^{-11} torr. Several gauge styles are available to meet a variety of pressure measurement requirements.

Nude gauges are recommended for bakeable, all-metal ultra-high vacuum systems where maximum exposure to the vacuum gives the highest possible accuracy. Nude gauges are available with replaceable single or double filaments.

Glass gauges are ideal for glass high vacuum systems or where some degree of protection for the gauge is required. The 7052 glass gauges are available in a variety of connecting materials... Pyrex, Nonex, Kovar and Kovar on a ConFlat® Flange. All glass gauges are equipped with double filaments.

PRINCIPLE OF OPERATION

The Varian Ionization Gauge contains three elements—filament, grid, and collector wire. The filament serves as a source of electrons. The grid functions as the electron collector operating at a positive potential (typically +130 volts) with respect to the filament. Along the center of the cylindrical grid structure is a very small diameter ion collector wire which operates at a negative potential (typically 45 volts) with respect to the filament. Electrons from the filament pass through the grid several times on the average before being collected at the grid. While passing through the interior of the grid structure the electrons ionize gas molecules at a rate which is proportional to the gas density. The positive ions produced on the inside of the grid structure are accelerated toward and neutralized at the collector by electrons from the external circuit. The number of ions produced per electron is proportional to gas density, and the positive ion current to the ion collector is used as an indication of pressure. Thus, for a constant value of accelerating voltage in excess of the ionization potential of the gas, the number of positive ions formed should vary linearly with pressure and with electron current. This is described by the relation $i_c = S\ p i_g$ where i_c is the ion current in amps to the collector, i_g is the electron current in amps to the grid, and p is the pressure in torr. The sensitivity, S, of a given ion gauge is the proportionality constant in the basic ionization gauge equation above. Thus:

$$S = \frac{1}{p}\ \frac{i_c}{i_g}$$

For Varian gauges, S for air is 25 $(\text{torr})^{-1}$. The normal operating electron current is 4 ma. Under these conditions the ion current at a pressure of 10^{-9} torr is 10^{-10} amps, etc.

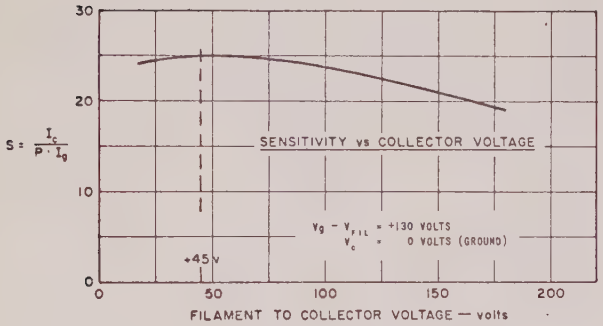
INSTALLATION

Both nude and glass envelope ionization gauges may be installed and operated in any position. Nude gauges should be installed in a relatively open space to reduce wall outgassing due to localized heating by the filament. When the gauges are mounted horizontally it is recommended that the filaments be positioned to the side of the grid rather than below or above so that slight vertical movement of the grid or filament will not change their relative spacing.

Varian Ion Gauge Connector and Cable Assembly Model No. 971-0012 is designed to mate with both the nude and glass envelope gauges. To make a proper connection the ridge located on the circumference of the connector should be aligned with the notch on the flange face of the nude gauge (either of the two notches on the dual filament nude gauge) or with one of the two marks painted on the surface of the glass envelope gauge. Proper connection will be made with the pins on both the nude and glass envelope gauge when the connector is ¼-inch from the ceramic spacer or glass base. DO NOT ATTEMPT TO FORCE THE CONNECTOR.

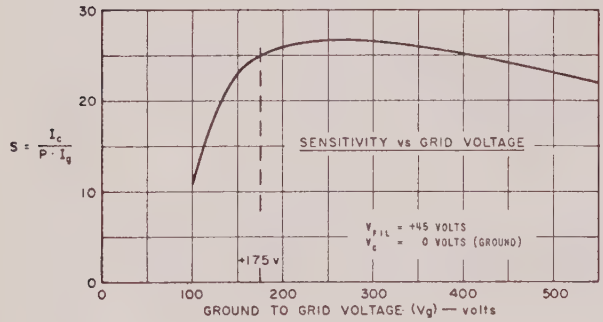
Varian Ionization Gauges may be operated with any ion gauge control unit capable of supplying the necessary operating voltages and currents. Degassing of Varian gauges is accomplished by electron bombardment of both grid and collector. Some makes of control units, however, do not have the electron bombardment feature. If this is the case, a degas power supply, a circuit for which is shown on page 4, may be constructed.

VARIAN IONIZATION GAUGE CHARACTERISTICS
UHV-12 AND UHV-14 MODELS

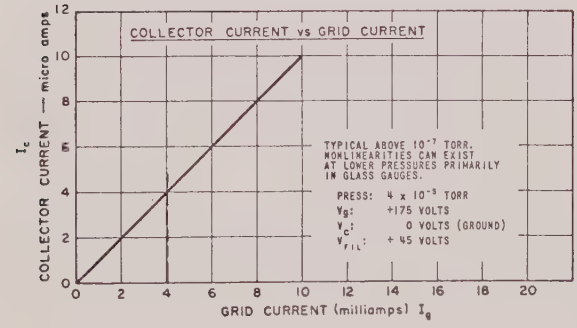

SENSITIVITY vs COLLECTOR VOLTAGE
$S = \frac{I_c}{P \cdot I_g}$
$V_g - V_{FIL}$ = +130 VOLTS
V_c = 0 VOLTS (GROUND)
+45 V
FILAMENT TO COLLECTOR VOLTAGE — volts

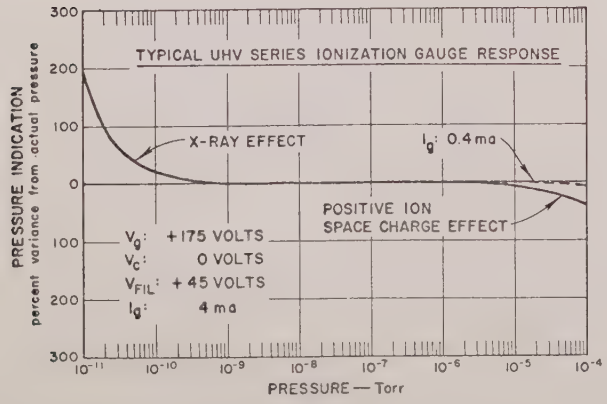
S = SENSITIVITY (TORR^{-1})
I_c = COLLECTOR CURRENT (AMPS)
I_g = GRID CURRENT (AMPS)
P = PRESSURE (TORR)

V_g = GRID VOLTAGE
V_c = COLLECTOR VOLTAGE
V_{FIL} = FILAMENT VOLTAGE



VARIAN IONIZATION GAUGE CHARACTERISTICS
UHV-12 AND UHV-14 MODELS


COLLECTOR CURRENT vs GRID CURRENT
I_c COLLECTOR CURRENT — micro amps
TYPICAL ABOVE 10^{-7} TORR. NONLINEARITIES CAN EXIST AT LOWER PRESSURES PRIMARILY IN GLASS GAUGES.
PRESS: 4 x 10^{-3} TORR
V_g: +175 VOLTS
V_c: 0 VOLTS (GROUND)
V_{FIL}: + 45 VOLTS
GRID CURRENT (milliamps) I_g



OPERATING SPECIFICATIONS

Normal Operating Requirements

Filament Voltage: 3 to 4.5 volts.

Filament Current: 2.5 to 3.5 amperes when current flowing from filament to grid is 4 ma d.c.

Grid Voltage: +130 volts d.c.
(referred to filament potential).

Collector Voltage: —45 volts d.c.
(referred to filament potential).

Voltages typically used: $V_c = 0$
$V_{fil} = +45$
$V_g = +175$

Degas Power Requirements (40 watts)

Grid and Collector Voltage: +400 volts d.c.

Grid and Collector Current (total): 100 ma d.c.

Filament Voltage: 7 volts.

Characteristics

Pressure in torr = 10 x collector current (i_c) in amps when the filament to grid current is 4 ma. Refer to the accompanying graphs for typical gauge characteristics.

Materials

Filament: tungsten.

Collector: .005-inch diameter tungsten wire.

Grid: platinum-iridium alloy
molybdenum support rods
(tungsten on earlier gauges)

OPERATION

Degas

A new ionization gauge should be degassed for about one hour. The gauge structure and materials have been leak checked at the factory, but the parts have not been vacuum fired. In the case of a nude ionization gauge that has been degassed when new and kept clean, the effects of subsequent degassing or not degassing will usually be small. This is because the surface areas that are degassed will usually be much smaller than the other surface areas in the chamber.

In gauges connected to systems through tubulations, a degassing step will usually result in a lower reading when the gauge has cooled. This lower pressure reading is often a transient condition arising from pumping by the cleaned surfaces; usually the readings will increase with time until equilibrium is established. For the transient condition to disappear, elapsed time of several minutes at 10^{-5} torr, several hours at 10^{-7} torr, and several days at 10^{-9} torr may be required. From the end of degassing until equilibrium is established, the pressure may change by a factor of 2 or 3 or even more. A convenient way to recognize this effect is to plot the pressure readings vs. time on either log-log or semi-log paper.

Bakeout

450°C is a safe maximum for repeated or extended bakeout of the nude gauge. In any case, 550°C must not be exceeded. Avoid exposing the gauge to thermal shock.

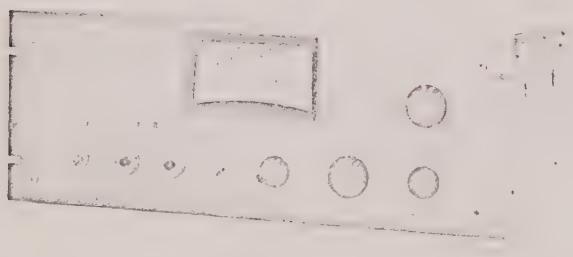
MAINTENANCE

Filament Replacement

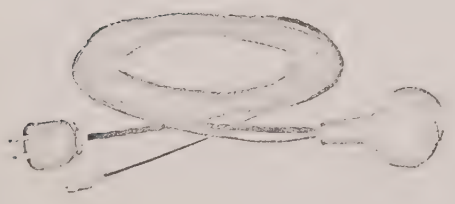
The glass gauge is equipped with two tungsten filaments. If one filament becomes damaged, the other may be put into service by removing the connector plug and rotating it 45° aligning the connector ridge with the second painted notch on the gauge, then reinstalling it. Apply the same procedure for the dual filament nude gauge.

The filament of the nude gauge may easily be replaced if it is damaged or broken. The Varian Replacement Filament Kit, Model No. 971-0009 contains three filaments and a wrench. (Kit Model No. 971-0018, for the dual filament UHV-24 nude gauge, contains one filament assembly and a wrench).

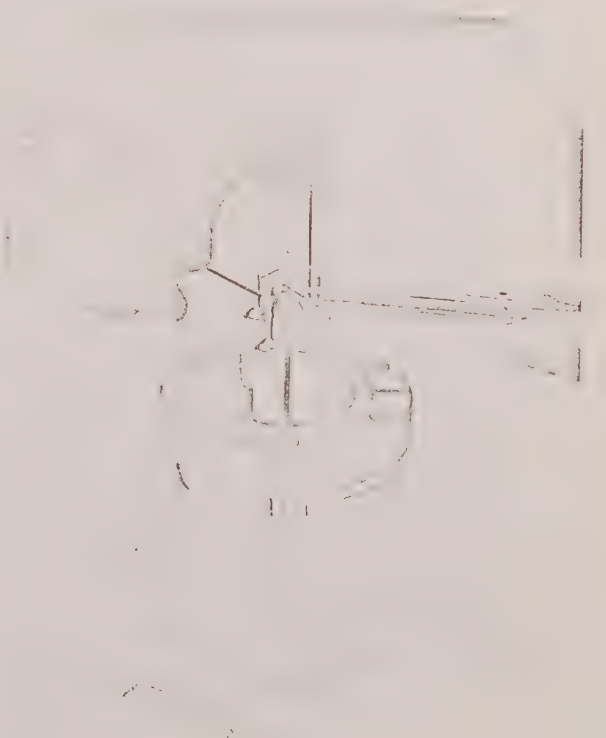
To remove the damaged filament, loosen the set screws and pull the old filament support brackets out. Install the new filament by inserting the long filament support bracket into its collar so that the filament will be located .050-.070 inches from the grid structure. Tighten the set screw. Next insert the short filament support bracket into its collar, *pushing it in as far as it will go* before retightening set screw. This will assure proper tension on the filament. The glass jar in which the filaments are shipped is intended to hold the nude gauge while replacing the filament.



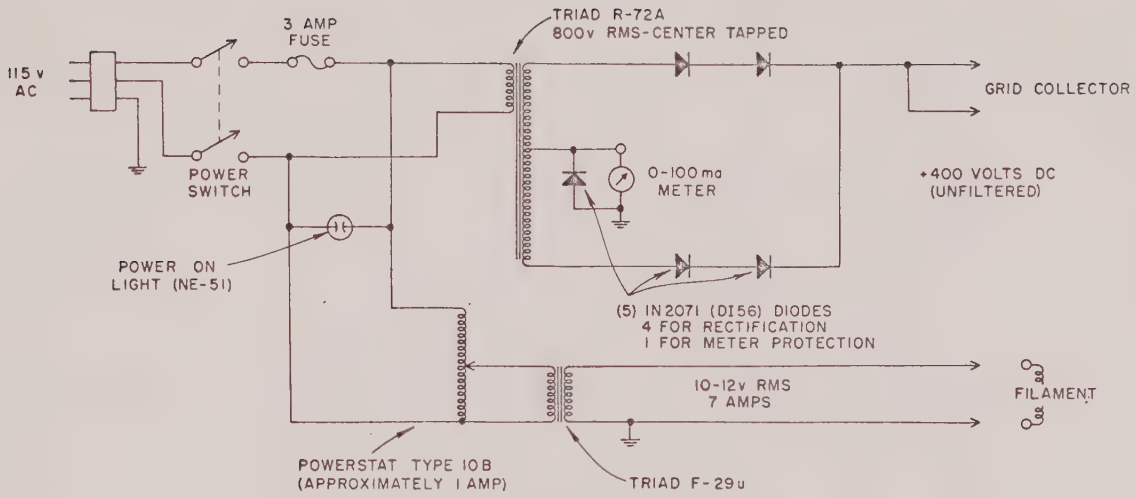
The Varian Ion Gauge Control Unit



Ion Gauge Cable and Connector Assembly
(Bakeable to 250°C)



Bottoming the short filament support bracket
before tightening the set screw.

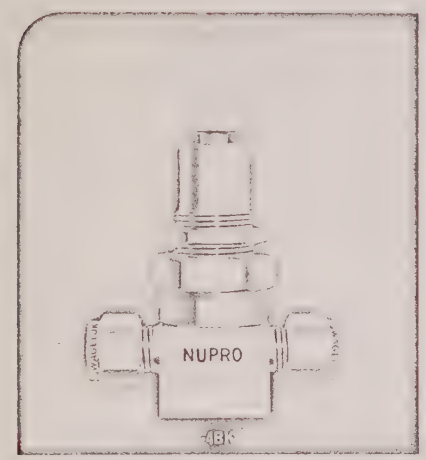


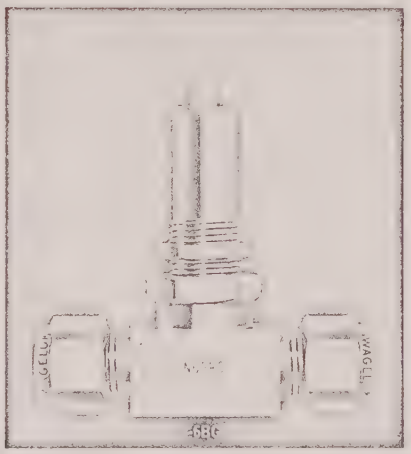
POWER SUPPLY FOR DEGASSING ION GAUGE
BY ELECTRON BOMBARDMENT

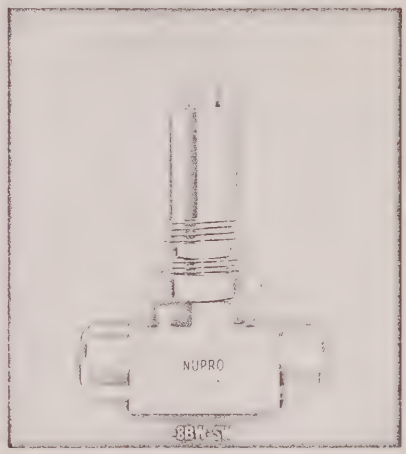
HOW TO ORDER

Address all orders and inquiries to the Varian District Office nearest you (consult Price List for location) or to Varian Associates, Vacuum Products Division, 611 Hansen Way, Palo Alto, California. European orders should be addressed to Varian A. G., Baarerstrasse 77, Zug, Switzerland. All products should be ordered by name and model number with desired options specified.

VAC 2117 (Printed in U.S.A. 4M164)







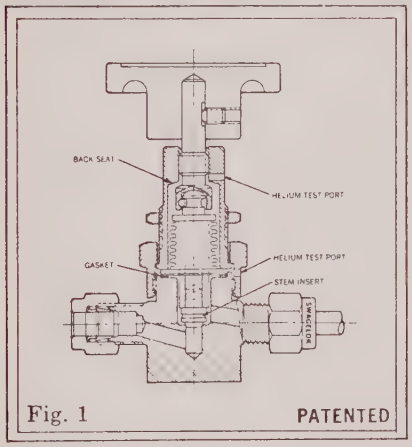


Fig. 1 PATENTED

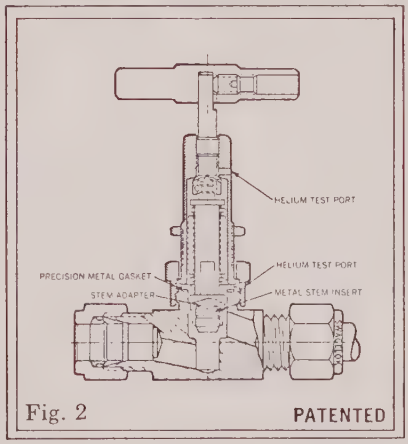


Fig. 2 PATENTED

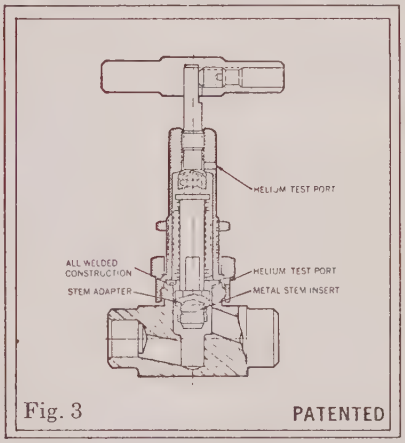


Fig. 3 PATENTED

NUPRO "B" Series Bellows Valves are available in Brass or 316 Stainless Steel with ¼", ⅜", or ½" SWAGELOK and various weld connections. Tube extensions can be supplied on request. Monel valves are also available on special order.

The "BK" Series is a bellows valve with a replaceable bellows and stem assembly using a KEL-F gasket and stem insert. Reference to Fig. 1 shows the KEL-F stem assembly in the "4BK" model. The KEL-F insert on *all* valves is supported over its entire length by a metal stem adapter. The soft seat design is excellent on vacuum work or where dead tight shut-off must be maintained with repetitive on-off service.

The "BG" Series is a bellows valve with a replaceable bellows and stem assembly using a metal stem or stem insert and a precision metal gasket. (See Fig. 2).

The "BW" Series is an all welded, hermetically sealed valve using a metal stem or stem insert. (See Fig. 3). The bellows and stem assembly are not replaceable and the valve cannot be disassembled. The all welded design is excellent for cycling temperature applications. ("BW" not available in brass).

PURPOSE

NUPRO "B" Series Bellows Valves were designed to handle a variety of difficult fluid control tasks.

APPLICATIONS

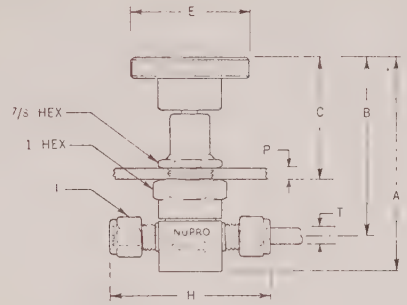
Usage with toxic, hazardous, corrosive or expensive fluids is recommended. High temperature vacuum work, liquid metal handling and usage as shut-off valves in sampling systems are other applications.

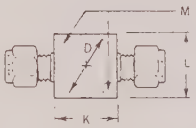
OPERATION

NUPRO "B" Series Bellows Valves are operated by simply turning the handle. Approximately two turns opens "4B" Series valves to full flow, while "6B-8B" Series valves require about four turns.

FEATURES

Reliable *positive stem return* is insured by the actuator-pin design. Some bellows valves tend to stick shut because of the fluids and temperatures used with them. In NUPRO "B" Series Bellows Valves, the pin engages a shoulder on the stem, and lifts it free if sticking occurs. *Back seat sealing* is accomplished by turning the valve handle to the fully open position. This prevents the escape of fluid in the event of a bellows rupture. The back seating is below the *helium test port* and thus shuts it off. Other standard features include 100% Helium leak testing • Union bonnet design • Panel and Bottom mounting • Low operating torque • Protected threads • Heli-arc welding and Non-rotating stem. On special order a *variety of stem inserts* can be supplied. Hastelloy "B", Hastelloy "C", hardened 17-4PH and #6B Stellite are available.





BOTTOM VIEW

WELD BODY

TABLE OF DIMENSIONS

	A	B	C	D	E	F	H	K	L	M	2—#10-32 TAPPED HOLES ¼" DEEP	N	S	W	T	P
-4BK -4BG -4BW	3 9/16	3 1/2	3	2 5/32	1	1 7/8	2 1/2	9/16	1	1		3/8	1/4	—	—	—
-4BK-SW -4BG-SW -4BW-SW	3 9/16	3 1/2	3	2 5/32	1	1 7/8	—	—	1	1		3/8	—	3/8	1/4	1 11/16
-6BK -6BG -6BW	4 3/16	4 3/32	3 11/16	2 5/8	1 1/8	2 1/2	3 1/8	1 11/16	1 1/2	1 1/8		3/8	3/8	—	—	—
-6BK-SW -6BG-SW -6BW-SW	4 3/16	4 3/32	3 11/16	2 5/8	1 1/8	2 1/2	—	—	1 1/2	1 1/8		3/8	—	1/2	3/8	2 1/4
-8BK -8BG -8BW	4 3/16	4 3/32	3 11/16	2 5/8	1 1/8	2 1/2	3 5/16	7/8	1 1/2	1 1/8		3/8	1/2	—	—	—
-8BK-SW -8BG-SW -8BW-SW	4 3/16	4 3/32	3 11/16	2 5/8	1 1/8	2 1/2	—	—	1 1/2	1 1/8		3/8	—	3/4	1/2	2 1/4

○Dimensions shown with SWAGELOK nuts finger-tight. ▲Drill panel 49/64" diameter for mounting.

MATERIALS

Round Handle—Hunter green phenolic plastic with hardened steel set screws in all "4B" Series valves

Bar Handle—Aluminum, anodized Hunter green with hardened steel set screw in all "6B-8B" Series valves

Pin—Hardened 420 Stainless Steel

Actuator—Hardened 416 Stainless Steel

Bellows—Type 321 Stainless Steel in all valves

Stem, Ring—Type 316L Stainless Steel in all valves

Stem Adapter—Type 316 Stainless Steel

Body—Type 316L Stainless Steel or Brass

Stem Insert, Gasket—

"BK" Series—Unplasticised type 81 KEL-F with Brass or stainless valves

"BG" Series—Integral stem on "4B" Series. Type 316 Stainless Steel stem insert on "6B-8B" Series. Aluminum gasket with Brass valves; annealed type 316 Stainless Steel gasket with stainless valves

"BW" Series—All welded design not available in Brass. No gasket is used. Integral stem on "4B" Series. Type 316 Stainless Steel stem insert on "6B-8B" Series

All Other Parts—
Type 316 Stainless Steel or Brass

FLOW COEFFICIENT	C_V=.36	C_V=1.01	C_V=1.21
DEAD SPACE (APPROX.)	0.1 cu. in.	0.24 cu. in.	0.26 cu. in.
BODY ORIFICE	0.172 inches	0.312 inches	0.312 inches
PORT ORIFICE	0.172 inches	0.281 inches	0.312 inches
PRESSURE RATING MAX.*	1000 P.S.I.	1000 P.S.I.	1000 P.S.I.
PRESSURE RATING@600°F	400 P.S.I.	400 P.S.I.	400 P.S.I.
PRESSURE RATING@900°F	200 P.S.I.	200 P.S.I.	200 P.S.I.

*Due to the strength of Brass threads, the cycle life of Brass valves will be limited when operated frequently at pressures above 450 P.S.I.

VALVES WITH KEL-F STEM INSERT OR GASKET	300°F MAX.
ALL OTHER BRASS VALVES	500°F MAX.
STAINLESS "BG" OR "BW" SERIES VALVES	600°F MAX.
STAINLESS "BW" SERIES ALL WELDED VALVES WITH STELLITE OR 17-4PH STEM INSERTS	900°F MAX.

WHEN VALVE SEAT IS °F	VALVE HANDLE IS °F
600	195
900	275

SOLENOID OPERATED
Vacuum
TYPE SV

SOLENOID OPERATED Vacuum Valve

Type SV

VEECO's Type SV Solenoid Vacuum Valve is unique in design;* we believe it to be the only solenoid valve commercially available which is qualified for high vacuum service.** A solenoid operated valve, suitable for use in high vacuum systems, has to satisfy the same requirements as a manually operated valve. The VEECO Solenoid Valve does this. Outstanding features are:

FEATURES

- Freedom from Leakage
- High Flow Conductance
- Minimum Outgassing
- Thousands of cycles without maintenance
- Flange Connections
- Continuous Duty Rating
- 115 V., AC operation

Reference to the line drawing will show that the Veeco Solenoid Valve requires no stem seal since the moving member is enclosed entirely within the valve body. Stem leakage is therefore impossible. The seat seal is made by an O-ring set into one of the two units which make up the valve disc. These units are forced apart by a wedge action when the valve is closed, so that the O-ring is pressed against the smoothly machined forged brass body. Tightness of both seat and bonnet seals is absolutely assured by test with the Veeco Mass Spectrometer Leak Detector.

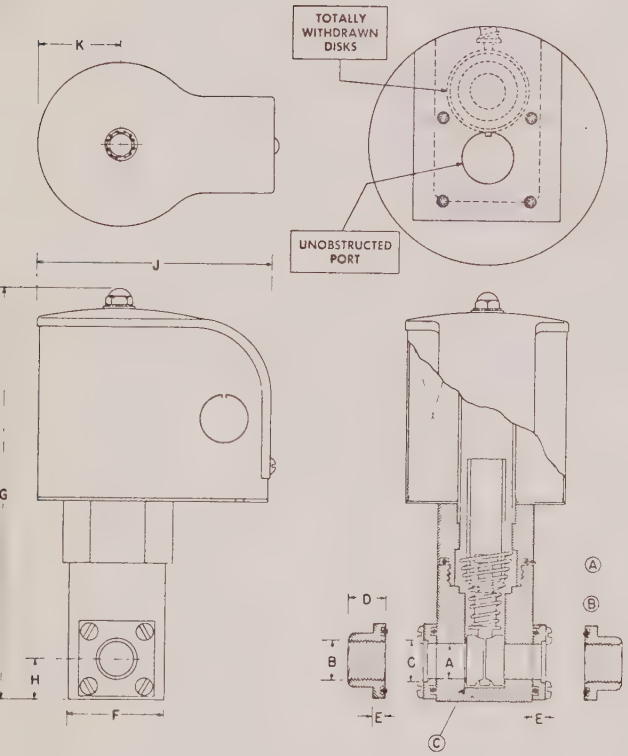
Another unique feature of these valves is their high conductance. The flow path is straight through and very short, and the ports are almost completely unimpeded. The exceptionally large travel of the stem withdraws the disc entirely into the upper part of the valve.

The seat-sealing O-ring, bonnet O-ring, and expanding pin are the only non-metallic elements in the valve. Since all O-rings are small in area, and one of them is "hidden" from the vacuum system, outgassing is at a minimum.

*Patent applied for.

**For automatic operation, see Thermocouple Controller sheet in the gauge section of this catalog.

SOLENOID OPERATED
VACUUM VALVE
TYPE SV



The valve is supplied with either one of two types of companion flanges: one type is designed to be brazed to 3/4" O.D. lines; the other is designed for 1/2" pipe connections. The valve can therefore be easily removed from the lines for maintenance. Alternatively, the bonnet and stem assembly can be removed. This is accomplished by simply unscrewing the bonnet; the hex nut supplies a convenient wrench-hold.

As has been pointed out above, the valve has exceptionally high conductance. It is therefore entirely feasible to place the valve in lines larger than 3/4" O.D. without undue restriction in flow.

The Solenoid Valve finds application wherever a quick-acting and automatic device is required. Typical uses are in automatically operated vacuum systems, as a safety device and as a remote-control valve.

The solenoid housing is provided with knock-outs for convenient attachment of electrical utilities. The housing may be rotated through 360° to any convenient position.

Operation is from 115 V AC or DC supply. The valve is normally closed. Holding current is 0.7 amps; inrush current is 3 amps, with AC operation; holding current is 0.25 amps for DC operation. Dimensions for DC valves are the same as AC valves (see chart).

Catalog No.	A Port Dia.	B Pipe Size	C Tubing O.D.	D	E	F Square Stock	G	H	J	K	Ⓐ	Ⓑ	Ⓒ
SV62S	5/8"		3/4"		1/4"	1-3/4"	7-1/2"	3/4"	4-1/4"	1-1/2"	1820-25	1820-17	1820-13
SV62P	5/8"	1/2"		3/4"		1-3/4"	7-1/2"	3/4"	4-1/4"	1-1/2"	1820-25	1820-17	1820-13

Available for 115 or 230v, 50 or 60 cps, AC or DC. See Price List. Specify desired parameters on purchase order.

GRANVILLE-PHILLIPS COMPANY

VACUUM EQUIPMENT

FOR USE FROM ATMOSPHERIC
TO THE
LOWEST PRESSURES ATTAINABLE

GRANVILLE-PHILLIPS COMPANY
5675 EAST ARAPAHOE AVENUE • BOULDER, COLORADO, 80302, U.S.A.
PHONE 303/443-7660 • TELEX 045-791

Granville-Phillips Company
5675 East Arapahoe Avenue • Boulder, Colorado 80301, USA
Area Code 303 443-7660

SERIES 244, 250 AND 251

CRYOSORB* COLD TRAPS

INSTALLATION AND OPERATING INSTRUCTIONS

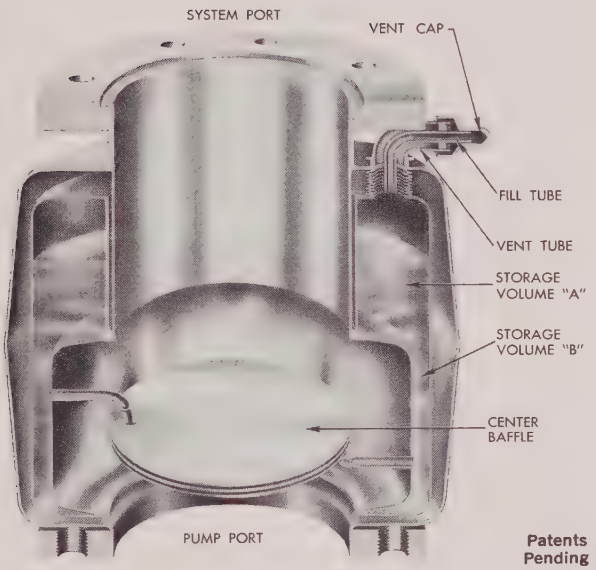


Figure 1. Cross section of Series 250 and 251 Cryosorb* Cold Traps

You have purchased what we believe to be the best designed and most carefully built cold trap that is presently commercially available. If it is properly installed and used, it will outperform any other cold trap. We suggest you take a moment to completely read the following before installing and filling your Cryosorb* Cold Trap.

DESIGN

The interior design of the Series 250, 4 inch, and the Series 251, 6 inch Cryosorb* Cold Trap is shown in Figure 1.

The Series 244, 2 inch Cryosorb* Cold Trap is identical in design except that the center baffle is cooled by conduction through the baffle support. Cryosorb* Traps are intended for use only with liquid nitrogen and installed with the axis of the trap vertical.

INSTALLATION

1. Keep interior surfaces clean. Fingerprints and other contamination only add to the gas load the pumps must handle.
2. The best way of mounting a Cryosorb* Cold Trap is to symmetrically position two or more supports under the system port flange and to suspend the diffusion pump from the pump port flange. The diffusion pump should then be supported laterally to prevent accidental side motion and possible damage to the trap.

   Cryosorb* Traps are not intended to support the load of a bell jar or manifold on an unsupported system port flange. Large loads may cause the trap housing to deform, thus producing a thermal short. Large, heavy system components should be supported with independent mounting brackets.
3. Orient the trap with the system port up and with the fill tube pointing in the approximate desired direction. When attaching a diffusion pump to the pump port flange, select mounting bolts which, when tightened, will not protrude through the trap flange and damage the trap housing. Secure the diffusion pump to the trap.
4. Loosen the fill tube assembly mounting screw and swivel the fill tube assembly to point in a convenient direction for filling. Install the second screw and tighten both mounting screws finger tight plus one half turn.

   CAUTION

   Do not overtighten fill tube mounting screws. When the trap is located in a relatively inaccessible location, it may be desirable to extend the fill and vent tube to a more convenient location eg. through a system cabinet.
5. Make the system port connection.

FILLING THE TRAP

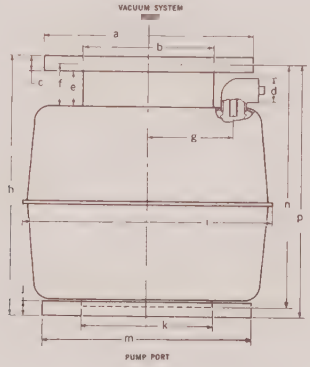
1. To obtain the lowest pressures, do not fill the trap until the system pressure is below about 10^{-4} torr, and until most of the water vapor in the system has been pumped out.
2. To fill the trap, connect a rubber or plastic hose between the ⅜" OD fill tube and the dispenser tube of the liquid nitrogen container. If the liquid nitrogen container is slightly pressurized, liquid nitrogen will flow in to the trap. Continue filling the trap until liquid nitrogen flows from the vent tube in a fair sized stream. Note that a few droplets of liquid nitrogen will flow from the vent tube throughout the filling operation. This condition is considered normal and should not be mistaken as evidence of a full trap. When a trap is initially cooled down from room temperature, it should be refilled after about 20 minutes to make up for the liquid nitrogen lost in the initial cooling of trap parts to cryogenic temperatures. This double filling is not necessary on subsequent refillings.
3. When the trap is used directly above a hot diffusion pump such as a 2 inch Veeco EP2AB or NRC Models HK750 and HS1500, these traps will hold a liquid nitrogen charge for more than 15 hours.
4. For maximum trapping efficiency, Cryosorb* Cold Traps have a built-in storage volume (Volume A in Figure 1) which is designed to maintain all trapping surfaces at a constant temperature for over 12 hours in the 2 inch trap, and for over 10 hours in the 4 and 6 inch traps. Therefore, for optimum performance the 2 inch trap should be refilled every 12 hours and the 4 and 6 inch traps refilled every 10 hours. Otherwise, the traps should be refilled every 15 hours. More frequent refillings may be required during system bakeout.
5. For automatic filling, a single inexpensive cycle timer and pressurizing valve may be used to automatically refill the trap at predetermined time every X hours. If an

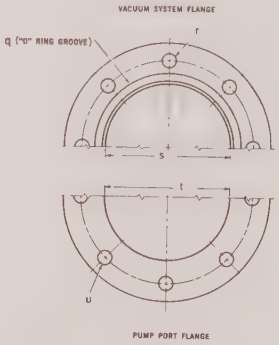
*Trademark of Granville-Phillips Company

automatic level controller is required, select one of the many available with a small flexible sensor which can be inserted through the trap vent tube.

HELPFUL SUGGESTIONS

1. Avoid ice build-up in the trap by keeping the fill and vent tubes and vent cap in place. If an automatic filler is used, arrange a slight constriction in the vent tube so that humid air cannot enter the trap. Do not pressurize the trap reservoir by more than 5 psig.
2. The bellows in the top of the trap is necessarily thin to prevent excessive heat transfer. To prevent damage to this bellows, always use the fill tube assembly provided with the trap. Under no circumstances should the bellows be deformed or gouged. Granville-Phillips Company will **NOT** be responsible for damage to the bellows.
3. When supplied with bakeable flanges or if welded directly to the system, the entire trap except for the Teflon gasket in the fill tube assembly is bakeable to 450°C. Remove the Teflon gasket before bakeout and make certain it is replaced after bakeout.
4. To clean the trap, remove the entire trap assembly from the system and immerse in trichlorethylene and then vapor degrease. Make certain all solvent is emptied from the inner passageways in the trap. Thoroughly dry the interior of the trap for several hours with a warm flow of air before reinstalling in the system.
5. The use of metal gaskets, even indium or lead, will usually lower the base pressure of a system one decade or so below that obtained through the use of organic gaskets.





DIMENSIONS IN INCHES

	DESCRIPTION	a ConFlat** Style	a ASA Type	b	c ConFlat** Style	c ASA Type	d	e	f	g	h	i	j	k††	m	n††	p	q	r ConFlat** Style	r ASA Type	s	t	u
SERIES 244 2 INCH CRYOSORB* COLD TRAP	FLANGED ON PUMP PORT AND WITH METAL TUBULATION ON SYSTEM PORT CATALOG NO. 244 001-202-230	NA	NA	2	NA	NA	⅞	NA	1 31/32	1 ⅞	NA	7½	5⅛	2 5/64	4	8 63/64	9 3/64	NA	NA	NA	1 ⅞	1 61/64	6 HOLES ¼-28 TAP ON 3 5/16 B.C.
	FLANGED ON BOTH PORTS CATALOG NO. 244 001-202-205	NA	4		NA	13/32		1½ Min.	NA		9 23/64						NA	2¾ OD x 2⅜ ID	8 HOLES DRILLED 21/64 ON 3⅝ B.C.	6 HOLES DRILLED 11/32 ON 3 5/16 B.C.			
	FLANGED ON BOTH PORTS CATALOG NO. 244 001-202-094	4½	NA		11/16	NA												NA					
SERIES 250 4 INCH CRYOSORB* COLD TRAP	FLANGED ON PUMP PORT AND WITH METAL TUBULATION ON SYSTEM PORT CATALOG NO. 250 001-203-231	NA	NA	5 9/16	NA	NA	⅞	NA	1 13/16	3⅝	NA	12	11/16	5 19/32	9	10 25/64	10 31/32	NA	NA	NA	5 19/64	5 7/16	8 HOLES ¾-11 TAP ON 7½ B.C.
	FLANGED ON BOTH PORTS CATALOG NO. 250 001-203-206	NA	9		NA	45/64		1½ Min.	NA		11 9/32						NA	5 5/16 OD x 5 ⅝ ID	20 HOLES DRILLED 21/64 IN 7⅛ B.C.	8 HOLES DRILLED 11/16 ON 7½ B.C.			
	FLANGED ON BOTH PORTS CATALOG NO. 250 001-203-235	8	NA		⅞	NA					11 13/32							NA					
SERIES 251 6 INCH CRYOSORB* COLD TRAP	FLANGED ON PUMP PORT AND WITH METAL TUBULATION ON SYSTEM PORT CATALOG NO. 251 001-276-280	NA	NA	7 11/32	NA	NA	⅞	NA	2 1/32	4½	NA	14⅝	15/16	7 11/32	11	11 5/32	11 31/32	NA	NA	NA	7	7⅛	8 HOLES ¾-16 TAP ON 9½ B.C.
	FLANGED ON BOTH PORTS CATALOG NO. 251 001-276-277	NA	11		NA	15/16		1½ Min.	NA		12 29/64						NA	7 ⅞ OD x 7 ½ ID	24 HOLES DRILLED 21/64 ON 9⅛ B.C.	8 HOLES DRILLED 13/16 ON 9½ B.C.			
	FLANGED ON BOTH PORTS CATALOG NO. 251 001-276-281	10	NA		31/32	NA					12 7/16							NA					

††Dimension for traps with weld tubulation on both ports.

Figure 2. Dimensions for Series 244, 250 and 251 Standard Cryosorb* Traps.

WARRANTY

The Company warrants that each item of merchandise sold by it is free from defective workmanship or material and it will replace or repair any item found to be defective in workmanship and/or material upon return of the same to the company office at Boulder, Colorado. The liabilities of the company arising out of supplying said products or their use, whether on said warranties or otherwise, shall in no case exceed the cost of correcting defects in the product. No other warranty expressed or implied, is assumed or will be assumed.

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Printed in USA

MOLECULAR SIEVE TRAPS

Instructions

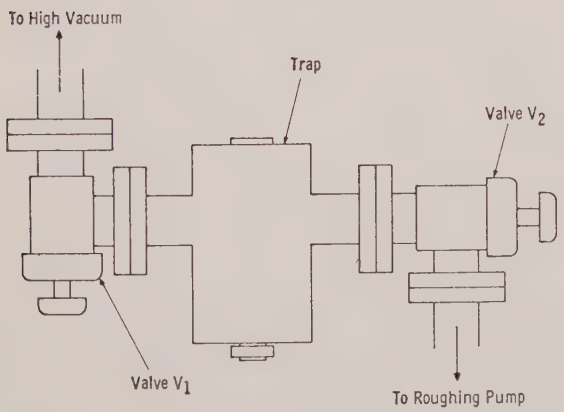
87-400 055

INTRODUCTION

The problems encountered in ultra high vacuum systems from backstreaming oil of mechanical roughing pumps and from water vapor, have necessitated the design of Varian molecular sieve roughing line traps. Varian 400 liter and 1400 liter traps protect vacuum systems from backstreaming oil and effectively pump water vapor. Removal of these condensables improves the starting and pump-down performance of VacIon® pumps.

OPERATION

The molecular sieve trap is intended for installation in the roughing line of a vacuum system. It is normally located between two isolation valves so that the mechanical pump may be vented and turned off when not in actual use. A typical arrangement is shown below.



In shutting off the roughing line from the vacuum system, Valve V_2 should be closed first. The trap will then continue to pump while the VacIon pump begins operation. Once the VacIon pump is operating, Valve V_1 is closed. Care should be taken to insure that the trap itself is kept under vacuum and not let back to air. If the mechanical pump is to be vented to air when not in use, Valve V_2 should be closed. Should the trap be exposed to air when not in use, a bakeout of the molecular sieve is normally necessary before re-use.

REACTIVATION OF THE SIEVE

The molecular sieve requires periodic reconditioning. The particular usage of the trap will determine the frequency of reconditioning the molecular sieve. This is accomplished by baking the sieve in the trap 'in place' and then allowing it to cool to room temperature in order to achieve the lowest base pressure during operation. An electric tubular heater is provided with Varian traps for molecular sieve bakeout. When not in use, the electric heater can remain in the trap during trap operation. During bakeout, the mechanical roughing pump should be turned on to assist in removing the entrapped vapor from the sieve. A simple timer switch (optional Varian Model 953-0033 or 953-0053) or an automatic 24 hour timer is recommended for control of the bakeout cycle. Use of such a device will permit the reconditioning to be done at odd hours, with the minimum interference with system operation.

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May, 1965

The 400 liter trap contains 56 grams of molecular sieve, and requires a bakeout of 35 minutes by the 60-watt, tubular heater. Capacity is herein defined as the number of liters of air at 50 percent relative humidity which can be pumped from atmospheric pressure through the trap before the system is limited to a base pressure equal to or exceeding 1.5×10^{-3} torr.

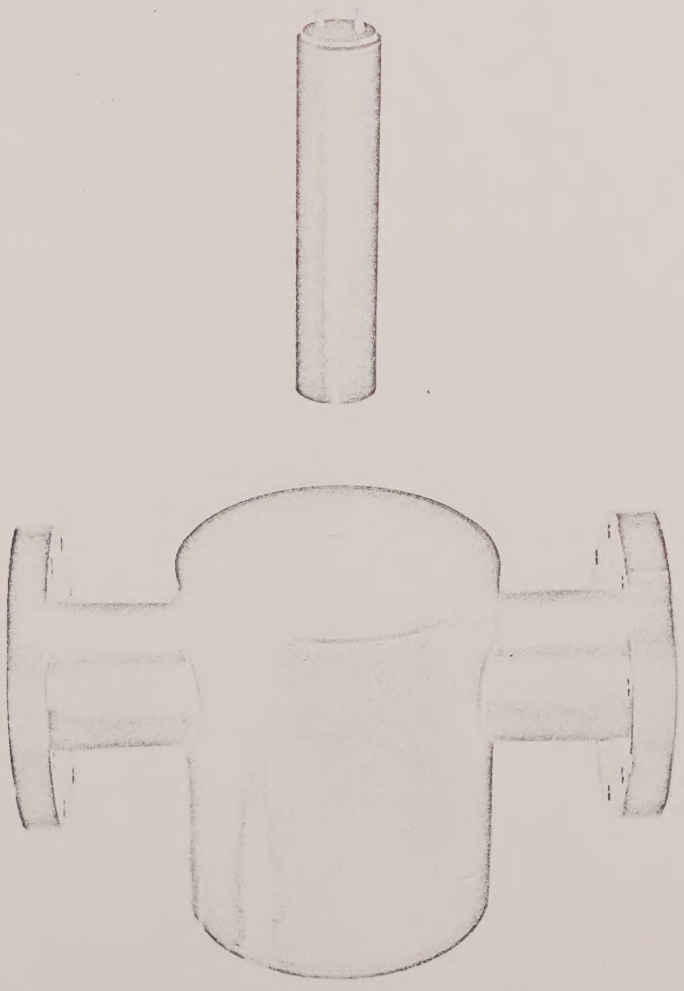
The 1400 liter trap contains 204 grams of molecular sieve and requires a bakeout of 60 minutes by the 175-watt, tubular heater.

REPLACEMENT OF SIEVE

The trap is filled with 13-X molecular sieve, 1/8-inch size Model 944-0002. To refill, first remove the sealing nut on the bottom of the trap and pour out the old sieve. Make sure to shake out all of the material. Measure the proper amount of sieve, pour it into the port opening, and shake vigorously to settle the sieve as much as possible. When the trap is filled to capacity, clean the sealing seat of sieve dust, insert copper gasket Model No. 953-0047, tighten the nut, and leak test the port seal.

ORDERING INFORMATION

Address all orders and inquiries to the Varian District Office nearest you (consult Price List for location) or to Varian Associates, Vacuum Products Division, 611 Hansen Way, Palo Alto, California. European orders should be addressed to Varian A.G., Baarerstrasse 77, Zug, Switzerland. All products should be ordered by name and model number.



VARIAN MOLECULAR SIEVE TRAP AND TUBULAR HEATER (MODEL 956-5001)

2-7B